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of the

American Ceramic Society

Abstracts
Vol. 9, No. 1

Bulletin
Vol. 9, No. 1

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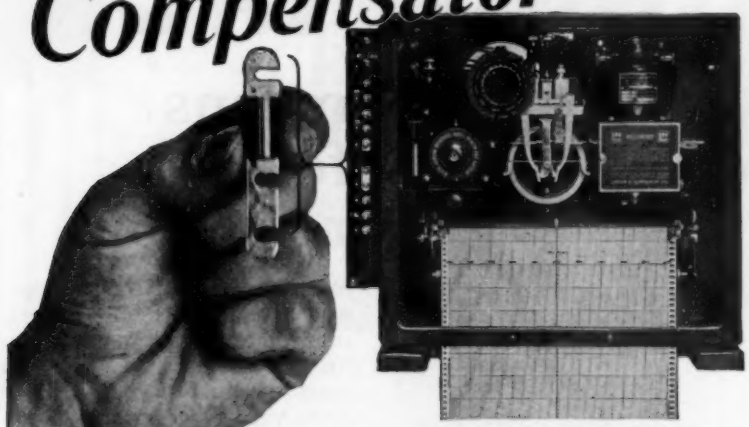

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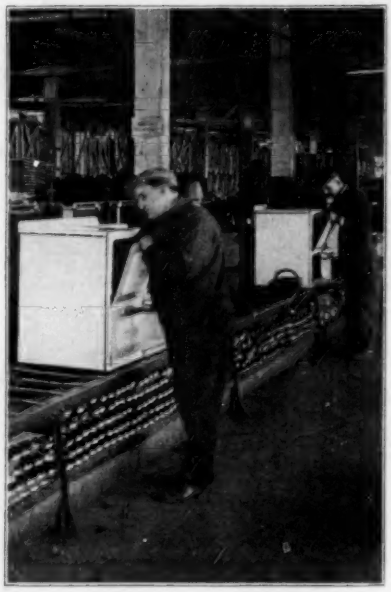

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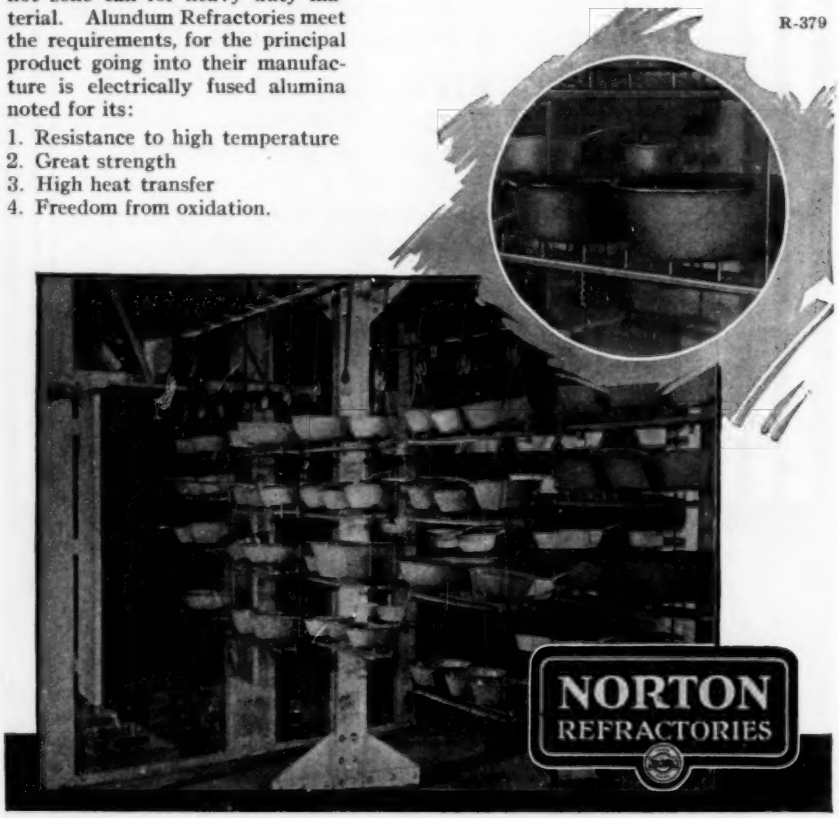

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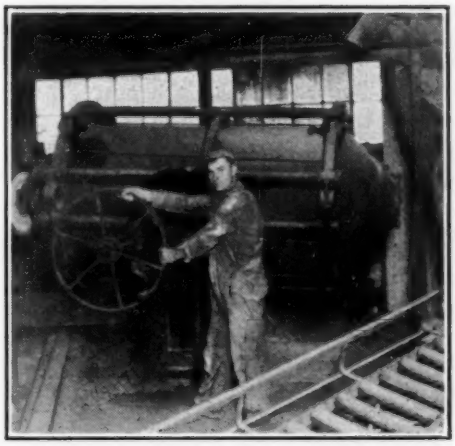

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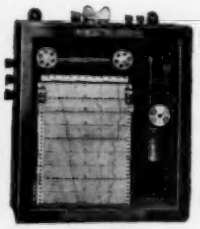

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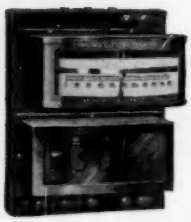

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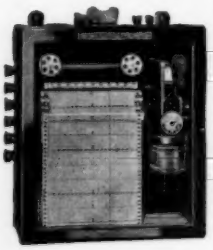

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A RAPID METHOD FOR THE ESTIMATION OF THE ALUMINA CONTENT OF DIASPORES AND HIGH ALUMINA CLAY[1]

By Stuart M. Phelps and A. C. Hughes[2]

ABSTRACT

A simple but rapid method is presented for the estimation of the alumina content of diaspores and high alumina clay. A comparison of results between chemical and physical analyses is given and even closer accuracy is promised with the use of an improved apparatus in process of construction.

Introduction

In the mining of high alumina clays and diaspore, the composition of the materials varies considerably throughout the pit. As it is highly desirable to classify the various grades, considerable hand-sorting is necessary and this work involves the estimation on the part of the miner of the probable alumina content. With considerable experience the miners are able to judge the alumina content within fairly close limits, but a more reliable, fairly quick method for determining the alumina is needed to eliminate personal errors.

Chemical analysis giving accurate alumina content requires days for completion and is expensive. A practical way of estimating the alumina could be based upon the physical characteristics of the diaspore.

Determinations were made to learn the relation between the density and alumina content of a number of aluminous clays. A definite relation was found and the range of densities was sufficiently wide to lead to the conclusion that a method based on this relation would be quite practicable.

The Method Used

Lumps in Kerosene Not Practical

Small pieces of clay weighing about 50 grams were dried, weighed, and saturated with kerosene. These pieces were then weighed while saturated with and suspended in kerosene. The apparent densities by this method were found to give fairly accurate results, but the procedure required nearly a day for a complete determination. Furthermore, it was observed that the clay is very apt to lose weight or slake and a number of pieces must be used in order to obtain a fair average.

The Final Method with Powder

The determinations should be made on powdered material to obtain better average samples and it should require only a matter of minutes for each determination. With this in mind the following procedure and apparatus were devised.

---

[1] Received September 19, 1929.

[2] Industrial Fellows, Mellon Institute of Industrial Research, Pittsburgh, Pa.

The Study Made

Figure 1 presents a photograph of the apparatus. In conducting a test, the plunger "B" is placed in the bottle with the bulb resting on the bottom. It is then filled with water, and the stopper "C" is inserted so that the stem of the plunger will project through the tube in the stopper. This assembly is shown in Fig. 2. The water level will be at the top of the glass tube in the ground-glass stopper. The stopper and plunger are removed from the bottle which will allow the water level to drop. The

FIG. 1.—Apparatus for rapidly estimating the alumina content for diaspores and high alumina clay.

FIG. 2.—Assembled apparatus.

displacement of the plunger and bulb is equal to the volume of the low density sample to be tested.

Twenty grams of the dry 40-mesh sample is then placed in the bottle. The stopper is inserted and the bottle is up-ended several times so as to completely wet the clay. The water level will have risen so that it is somewhere in the tube. The stem of the plunger is inserted into the bottle through the tube until the water level rises to the top. The depth of the immersion of the stem into the bottle is noted and this datum supplies an arbitrary figure for the volume of the 20-gram sample, or, in other words, for its apparent density.

A number of samples were tested in this simple apparatus, and in general,

the results were encouraging. The arbitrary value for bulk density was determined on a variety of diaspores, varying in alumina content from 45 to 80%. These values and the alumina contents, as determined by chemical analysis, were plotted as shown in Fig. 3.

The position of the points on the graph shows the relation between an apparent density and the alumina content.

TABLE I

DETERMINATION OF ALUMINA IN DIASPORE BY CHEMICAL AND PHYSICAL ANALYSES

Sample No.	Ignition loss (%)	Alumina in percentage —as determined by— Chemical analysis	Physical analysis	Error of rapid method (physical analysis)
1	13.72	48.95	56.8*	+7.8
2	13.00	51.51	50.2	−1.3
3	13.52	54.47	52.9	−1.6
4	13.96	61.80	61.2	−0.6
5	13.32	76.05	71.5	−4.6
6	13.62	77.53	79.2	+1.7
7	13.76	78.21	80.3	+2.1
8	12.96	49.53	49.9	+0.4
9	12.92	49.21	48.4	−0.8
10	12.76	63.79	52.9*	−10.9
11	12.40	62.51	59.7	−2.8
12	13.24	75.07	72.3	−2.8
13	13.08	74.42	70.8	−3.6
14	13.12	51.17	52.0	+0.8
15	13.80	49.72	50.5	+0.8
16	13.74	54.32	56.1	+1.8
17	12.02	59.71	60.1	+0.4
18	13.12	59.28	59.2	−0.1
19	13.80	57.42	57.5	+0.1
20	13.36	55.59	58.3	+2.7
21	14.08	67.27	67.5	+0.3
22	13.40	55.44	61.5*	+6.1
23	13.52	66.05	66.1	0
24	12.88	66.06	67.8	+1.7
25	13.84	74.48	70.0	−4.5
26	12.96	50.97	49.7	−1.3
27	13.76	60.31	58.5	−1.8
28	13.50	59.04	60.8	+1.8
29	13.22	60.49	64.4	+3.9
30	13.60	64.55	62.0	−2.6
31	13.64	66.24	65.4	−0.8
32	13.28	71.71	75.6	+3.9
33	13.48	70.96	68.5	−2.5
34	14.06	75.13	76.7	+1.6
35		71.08	72.6	+1.5
36		71.02	68.5	−2.5
37		66.77	70.4	+3.6
Average	13.37	63.52	63.3	−0.2

* Not included in average.

The average line of the graph was figured from thirty-three of the points, three being excluded by reason of their divergences.

Accuracy of Method The stem readings for the determinations of the various samples, converted into the alumina contents, are presented in Table I together with the alumina as determined

by analysis. The plus and minus errors of the rapid method are given and show the limits of accuracy that may be expected. The average of all the plus figures is 1.6%, the minus figures show 2.1%, while the standard deviation is ± 2.26%. Estimations as close as these are satisfactory for most types of control work. Greater accuracy may be expected with a more refined apparatus and the use of a larger number of samples to form the average line of Fig. 3.

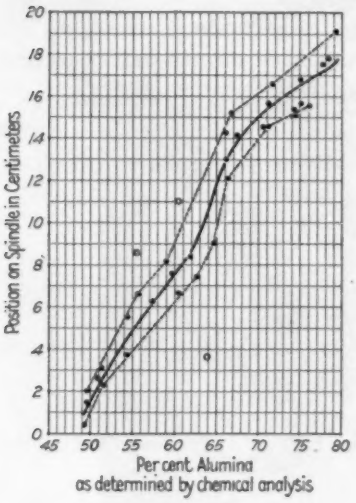

FIG. 3.

Time Required The time required for a determination on a previously dried and ground sample is four or five minutes. The drying and grinding of samples should not require more than an hour.

Loss on Ignition The loss-on-ignition data are given and are regarded as useful for calculating the alumina content on the calcined basis. The average figure of 13.4% should be satisfactory for most work.

Conclusion

This rapid method appears to be satisfactory for plant control work in determining the alumina content of high alumina clays and diaspore. The advantages of the method are simplicity, rapidity, the use of a powdered sample, and the comparatively high accuracy of the results.

An improved apparatus is being designed which will be even more accurate and more practical for plant use.

MELLON INSTITUTE OF INDUSTRIAL RESEARCH
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PHASE EQUILIBRIA IN THE SYSTEM SiO_2–ZnO[1]

By E. N. Bunting

ABSTRACT

A study of phase equilibria in the condensed system SiO_2–ZnO by the quenching method shows the existence of (*a*) only one compound, Zn_2SiO_4, the melting point of which is 1512°C; (*b*) a region of two immiscible liquid phases in equilibrium with cristobalite at 1695°C, extending from 2 to 35 mol. per cent ZnO; (*c*) a eutectic between tridymite and Zn_2SiO_4 at 1432°C and 49.1 mol. per cent ZnO; (*d*) a eutectic between ZnO and Zn_2SiO_4 at 1507°C and 77.5 mol. per cent ZnO. The melting point of ZnO is found to be 1975° ± 25°C.

An iridium vessel is described which can be used in an induction furnace to obtain constant temperatures up to 2300°C in an oxidizing atmosphere.

I. Introduction

Since the available data on phase equilibria in the SiO_2–ZnO system were very incomplete and contradictory, a rather complete study of this system has been made as a preliminary to an investigation of the ternary system SiO_2–ZnO–Al_2O_3.

The existence of a zinc metasilicate, $ZnSiO_3$, has been reported by several investigators.[2] Gorgeu,[3] however, could not obtain the metasilicate from melts of ZnO + SiO_2 with Na_2SO_4, only the orthosilicate being formed.

The orthosilicate, Zn_2SiO_4, is found as the mineral willemite. Stein gives the melting point of the synthetic compound as 1484°C and Jäger and Von Klooster give 1509°C.

II. General Method

Because of the low velocity of crystallization of molten silicate mixtures it was necessary to use the quenching method to study the equilibrium conditions. A small sample (10 to 20 mg.) of the mixture under investigation was enclosed in a platinum capsule and held at a constant temperature until equilibrium was attained between the phases present. It was then rapidly cooled, by dropping into water or mercury, so that no change in the equilibrium could occur, and the material examined under the petrographic microscope to identify the phases present.

Figure 1 shows the resistance furnace used. It was 40 centimeters

[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce. Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Glass Division.) This paper will be given publication in the *Journal of Research*, Bureau of Standards.

[2] Stein, *Z. anorg. allgem Chem.*, **55**, 159 (1907); Von Klooster, *Z. anorg. allgem. Chem.*, **69**, 142 (1910); Jäger and Von Klooster, *Proc. K. Acad. v. Weten. Amst.*, **18**, 896 (1916); Ebelmen, *Ann. Chim. Phys.*, [3] **33**, 34 (1851); Schulze and Stelzner, *Neues Jahrb. Mineral. Geol.*, **1**, 150 (1881); Traube, *Berichte*, **26**, 2735 (1893); Mulert, *Z. anorg. allgem. Chem.*, **75**, 220 (1912); Rüger, *Keram. Rundschau*, **31**, 100 (1923).

[3] Gorgeu, *Comp. rend.*, **104**, 120 (1887).

long and the heating unit consisted of 13.7 meters of wire,[4] 0.81 millimeter in diameter, made from an alloy containing 60% Pt and 40% Rh. About 1 kw. was required to hold it at 1700°C. The platinum capsule was suspended in the furnace chamber by means of a fine platinum wire attached to a larger platinum wire. After equilibrium was attained, the bottom plug was removed and the capsule dropped into water by pulling it up until its small supporting wire broke. Temperatures in the furnace were held constant with a modified thermostat of the type developed at the Geophysical Laboratory,[5] and were measured with a disappearing filament optical pyrometer sighted through the conical opening in the upper plug of the furnace. A calibrated Pt Pt-Rh thermocouple[6] placed in the center of the furnace chamber checked the temperature readings obtained with the optical pyrometer to within 2°C at 1400°C, both pyrometer and thermocouple being certified to ± 5°C at this temperature. At the higher temperatures up to 1700°C, the pyrometer was certified to ±10°C.

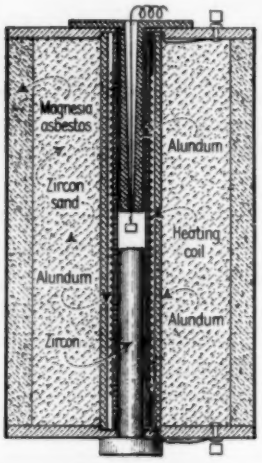

FIG. 1.—Diagram of Pt-Rh resistance furnace used in quenching experiments.

III. The SiO_2–ZnO Mixtures

The SiO_2–ZnO mixtures investigated were prepared from selected rock crystal (99.7% SiO_2 after grinding to 200-mesh) and zinc oxide specially prepared by the New Jersey Zinc Company and containing not more than 0.10% total impurities.[7] The mixtures were prepared in stick form and prefused in the oxyhydrogen flame. The fused material was pulverized in a steel mortar and ground in an agate mortar. Three fusions and grindings were made to insure a homogeneous mixture.[8] All mixtures were found to contain one to two tenths of a per cent of Fe_2O_3, introduced in the pulverizing process. The mixtures were all held at the furnace temperatures for one-half hour or more before quenching.

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[4] The wire was fabricated by the chemical metallurgy section of the Bureau of Standards. A pure Rh wire is now being used in this furnace.

[5] Roberts, *Jour. Opt. Soc. Amer. and Rev. Sci. Inst.*, **11**, 171 (1925).

[6] The optical pyrometer and thermocouple were calibrated by the pyrometry section of the Bureau of Standards.

[7] Analysis furnished by the New Jersey Zinc Company.

[8] All mixtures were analyzed by J. A. Scherrer of the analytical section of the Chemistry Division of the Bureau of Standards.

RESULTS WITH SiO_2–ZnO MIXTURES

Composition Mol. per cent ZnO	Furnace temp. °C	Phases present
1.8	1700	One glass
3.1	1695	2 glasses + cristobalite
19.7	1695	" " " "
27.0	1695	" " " "
31.2	1695	" " " "
34.3	1695	" " " "
37.4	1610	All glass
	1600	Glass + cristobalite
43.3	1530	All glass
	1520	Glass + cristobalite
44.5	1510	All glass
	1 00	Glass + cristobalite
46 2	1490	All glass
	1480	Glass + cristobalite
47.0	1470	All glass
	1465	Glass + tridymite
48.3	1465	All glass
	1455	Glass + tridymite
49.1	1435	All glass
	1430	Tridymite + Zn_2SiO_4
51.0	1440	All glass
	1435	Glass + Zn_2SiO_4
51.6	1450	All glass
	1445	Glass + Zn_2SiO_4
52.5	1455	All glass
	1450	Glass + Zn_2SiO_4
54.3	1460	All glass
	1455	Glass + Zn_2SiO_4
58.5	1490	All glass
	1480	Glass + Zn_2SiO_4
60.4	1505	All glass
	1500	Glass + Zn_2SiO_4
65.0	1515	All glass
	1510	Glass + Zn_2SiO_4
66.7	1515	All glass
	1510	Zn_2SiO_4
69.4	1515	All glass
	1510	Glass + Zn_2SiO_4
71.9	1515	All glass
	1510	Glass + Zn_2SiO_4
73.9	1510	All glass
	1505	Glass + Zn_2SiO_4
75.2	1510	All glass
	1505	Glass + Zn_2SiO_4
76.5	1510	All glass
	1505	Glass + Zn_2SiO_4
78.0	1540	All glass
	1535	Glass + ZnO
79.5	1570	All glass
	1560	Glass + ZnO
81.0	1590	All glass
	1580	Glass + ZnO
82.9	1610	All glass
	1600	Glass + ZnO

IV. Results

The data obtained are given in the table and in Fig. 2.

V. Discussion

These experiments show that only one compound, Zn_2SiO_4 (zinc orthosilicate), is formed at high temperatures. Its melting point is 1512°C ± 3°C. It forms a eutectic with tridymite at 1432°C and 49.1 mol. % ZnO, and a eutectic with ZnO at 1507°C and 77.5 mol. % ZnO. The optical properties of the Zn_2SiO_4 prepared agree closely with those of the natural mineral, willemite,[9] and are as follows:[10] Uniaxial positive (tetragonal or hexagonal), occurring as irregular grains with no characteristic crystal form or habit and with no good cleavage. Indexes of refraction for sodium light are $\omega = 1.692$, $\epsilon = 1.720$, both ± 0.003. Near the eutectic composition with tridymite, the Zn_2SiO_4 occurs as fine fibrous crystals, often as spherulitic radiating aggregates.

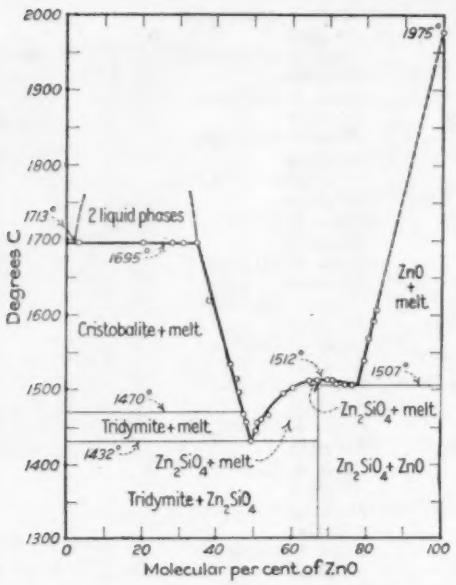

FIG. 2.—Phase diagram for the system SiO_2–ZnO.

No evidence of the existence of the metasilicate was found. Examination at high magnification (1000 ×) of the fully crystallized mixtures containing 49.1 and 51.0 mol. % of ZnO held at 1350°, 1300°, 1200°, and 1100°, respectively, for 70 hours each, showed them to contain only tridymite (25 to 30%) and zinc orthosilicate.[10] At a magnification of 100 to 200×, the material appears to be homogeneous and might easily be mistaken for a metasilicate. These same mixtures were also fused with sodium tungstate at 1000° for 72 hours and the melt extracted with warm water and dilute ammonia solution. Only zinc orthosilicate was found in the residue. X-ray spectrograms[11] of the mixtures, containing 51.6 mol. % ZnO, quenched at 1440°C, and 65.0 mol. % ZnO, quenched at 1505°C, showed identical patterns, proving the absence of a metasilicate in the region of 50 mol. % ZnO. X-ray spectrograms of

[9] *Amer. Mineralogist*, **10**, 187 (1927).

[10] H. Insley of the Bureau of Standards determined the optical properties and collaborated in the petrographic examination of some of the mixtures.

[11] X-ray spectrograms were made by E. C. Groesbeck of the metallurgical division of the Bureau of Standards.

the 48.3 mol. % ZnO and 51.6 mol. % ZnO mixtures held at 1350°C for two hours and containing tridymite with zinc orthosilicate were also identical.

The two liquid phases occurring at 1695° and between 2 to 35 mol. % ZnO were first noted by J. W. Greig.[12] The upper boundary of this region was not investigated as it is above the temperature attainable in the resistance furnace. The Ir-Pt alloy furnace described below (Fig. 3) could not be used for this purpose, as vaporization from the hole at high temperatures could not be prevented, and the mixture in the hole did not remain of uniform composition.

The melting point of cristobalite given as 1713°C in Fig. 2 is taken from the data published by J. W. Greig.[13]

VI. The Melting Point of ZnO

The only datum given in the literature on the melting point of ZnO is that it is above 1800°C.[14] As this is above the temperature obtainable in a platinum resistance furnace, it was necessary to design a furnace which could be operated at high temperatures in an oxidizing atmosphere in order to prevent the reduction of the ZnO. Iridium, with a melting point of 2300°C, is a suitable heating element since it does not oxidize when heated rapidly to temperatures above 1200°C.[15] Instead of pure iridium, an alloy with 27% platinum, melting at 2150°C, was employed in the form of a button which was formed by melting mixed Ir-Pt sponge in the bottom of a thoria crucible[16] (see Fig. 3). When this crucible was surrounded with an insulating layer of powdered thoria one-half inch thick, contained in an alundum thimble, the button within could be heated up to its melting point when placed in the high frequency field of an Ajax induction furnace. By adjusting the spark gap every minute or two, the temperature of the button could be held constant within ± 10°C. Temperatures were measured with an optical pyrometer sighted on the outer small hole, both holes giving the same reading when empty.

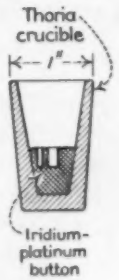

FIG. 3.—Crucible with iridium vessel used to obtain temperatures up to 2300° C in an oxidizing atmosphere.

A small piece of ZnO, which had previously been fused in the oxygen carbon arc, was placed in the center hole of the button and heated. Above 1950°C complete evaporation of the charge occurred within a few seconds.

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[12] Greig, *Amer. Jour. Sci.*, **13**, 137 (1927).

[13] *Ibid.*, **13**, 10 (1927).

[14] Libman, *Jour. Amer. Ceram. Soc.*, **5**, 488 (1922).

[15] The dissociation temperature of IrO_2. See Becker, Diss. Darmstadt, 1927.

[16] This crucible and Ir button were fabricated by the chemical metallurgy section of the Bureau of Standards.

When a layer of Ir-Pt sponge (of the same composition as the button) was tamped in above the powdered ZnO, a fused pellet of ZnO was obtained on heating to 1975° for a few seconds. A repetition of this procedure at 1960° did not fuse the ZnO, while at 1985° a fused pellet was also obtained. The optical pyrometer was used immediately after calibration and was certified to ± 25°C at this temperature.

Acknowledgment The author is indebted to E. W. Washburn of the Bureau of Standards under whose general supervision the work was done.

AN APPARATUS FOR THE DETERMINATION OF ADSORBED AIR[1]

By Hobart M. Kraner and Ray A. Snyder

ABSTRACT

Some possible ceramic applications of the Toepler mercury pump as employed in determination of gases in various materials are discussed. The procedure followed in measuring the gases given off by a clay slip at reduced pressures is described. It was found that 4.65% of gases by volume are removed from a sample of clay slip by reducing the pressure on the sample to boiling (25 mm.). An additional 0.18% of gases was evolved between the boiling pressure and 1.8 mm. at which pressure the sample was dry.

Introduction

The apparatus described herein is a simple modification of the Toepler pump as used for the determination of gases in metals. In such work the metal is melted under reduced pressures, and the gases released are measured and analyzed by fractionally separating in liquid air- and CO_2-cooled traps. The Toepler pump, which utilizes a mercury piston, has a number of other possible applications among which are the following:

(1) Measurement of absorbed and otherwise held gases present in such materials as bakelite and vacuum cement. In cases such as this, where only small quantities of water are present, the apparatus as shown in Fig. 1 is suggested. The liquid air trap is provided to freeze out the moisture in the system. The sample container is equipped with a resistance heater or high-frequency coil to heat or melt the sample.

(2) Measurement of gases present in such materials as clay slips. See Fig. 2.

(3) Measurement of air adsorbed on the surface of solid materials at ordinary temperatures. Figure 2 shows the apparatus as used in this work.

(4) Volume and porosity determinations may also be made by adaptations of this apparatus.

Apparatus

The apparatus used on clay slips is shown in Fig. 2. The Toepler pump, which is used for compression and circulation of the gases consists of two glass reservoirs, mercury piston, and suitable stop-cocks. The volume of the standard bulbs, A and B, were accurately determined by weighing the mercury required to fill the bulbs before assembling the apparatus. The manometer tubes, whose volumes at all heights are known, permit accurate determination of total volumes at all pressures. The manometers are read by means of a cathetometer solidly mounted on a base four feet from the apparatus. Obviously, an auxiliary vacuum system was necessary to reach the low pressures attained. Compressed air assisted in manipulating the piston.

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Illinois, February, 1929. (White Wares Division.)

Procedure

The volumes of the left and right sides of the apparatus were determined by expanding the air in bulbs A and B into the volumes to be determined. From the manometer readings, barometric pressure, and application of Boyle's law, etc., the unknown volumes were calculated.

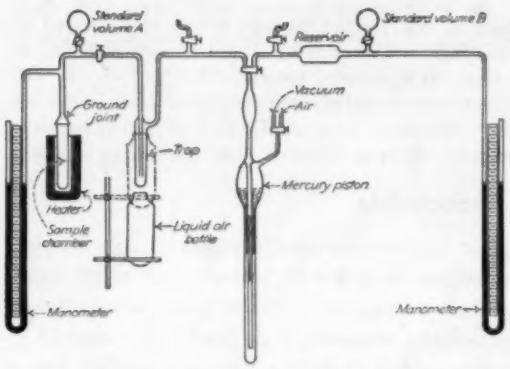

FIG. 1.—Apparatus for determination of adsorbed gases.

Example The material tested was a plastic process electrical porcelain slip consisting of 57% water and 43% solids, and having a specific gravity of 1.43. The sample, 66.47 cc. of the slip determined by weighing was placed in the container and the left side of the apparatus closed. After a few minutes, during which time the volume above the sample came to equilibrium by saturating with water vapor, the left manometer was read and the pressure within found to be slightly higher than barometric pressure. The cathetometer readings were 368.2 mm. and 365.5 mm. The difference between these readings added to the barometric pressure gave the pressure (P_1) within the apparatus.

$$P_1 = 738.5 + (368.2 - 365.5) = 741.2 \text{ mm.}$$

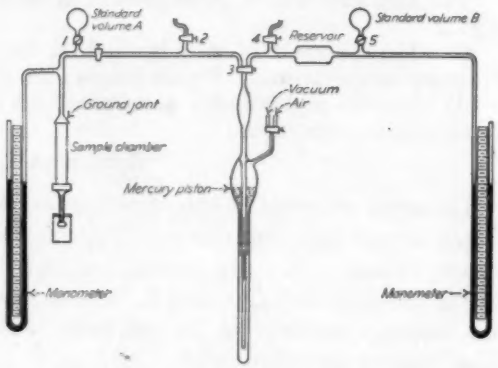

FIG. 2.—Apparatus for determination of adsorbed gases.

The volume (V_1) of gases contained in the left side at the pressure P_1 was

$$V_1 = 241.45 - 66.47 + 0.05 = 175.03 \text{ cc.}$$

where 241.45 cc. was the volume of the left side of the empty apparatus as calibrated, 66.47 cc. the volume of the slip used, while 0.05 cc. is a correc-

tion which was added for the increase of volume occasioned by the depression of the manometer mercury column.

To obtain comparative values for the volumes, they were corrected to atmospheric pressure:

$$V = \frac{175.03 \times 741.2}{738.5} \text{ or } V = 175.67 \text{ cc.}$$

where V is the original volume of gases contained in the left side at a pressure of 738.5 mm.

The next step was to decrease the pressure on the slip as follows: The mercury in the pump was forced into the upper bulb to the stop-cock No. 3 by exhausting the air in the pump through stop-cock No. 4 and to the atmosphere; then the two-way stop-cock No. 3 was turned so as to connect the pump to the left side, and the mercury allowed to drop, thus expanding the gases present in the left side of the apparatus until there had been a considerable reduction in pressure. The manometer was read and the pressure calculated. It was found to be 404.7 mm. The mercury was next forced back to its former position and the manometer again read, the readings being 370.3 and 363.4 mm., so that

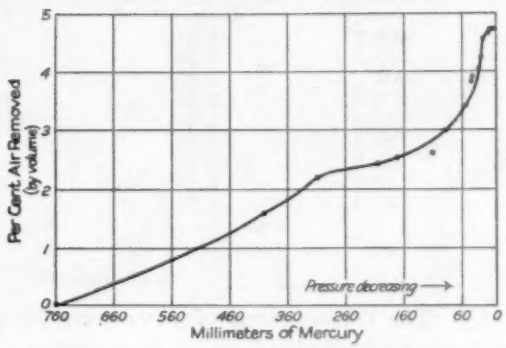

FIG. 3.

$$P_2 = 738.5 + (370.3 - 363.4) = 745.4 \text{ mm.}$$

Since the temperature remained constant at 25°C this increased pressure must have been caused by gases which were removed from the slip.

The volume V_2 thus becomes:

$$V_2 = 241.45 - 66.47 + 0.12 = 175.10 \text{ cc.}$$

and at atmospheric pressure:

$$V_3 = \frac{745.4 \times 175.10}{738.5} \text{ or } V_3 = 176.74 \text{ cc.}$$

and the volume increase $(V_3 - V)$ was 1.07 cc. when the pressure on the slip was reduced to 404.7 mm. or the per cent volume of air liberated was 1.61.

Determinations were made at successively lower pressures until the boiling pressure of the slip had been reached. Here the pressure in the

left side remained constant at the vapor pressure of water. With constant pumping of water vapor from the left to the right side, the moisture was extracted from the slip and stored in the right side which was held at reduced pressure to insure against reabsorption of the gases by the water. When there was no longer sufficient water present in the left side to produce saturation the pressure on the clay was reduced further and readings taken as before. Data were thus obtained to show the amount of air given off by the dry clay residue at pressures below that of the boiling point of the slip, after the slip had been boiled dry by continuous pumping.

Figure 3 gives a curve showing the percentage of air by volume removed from the slip at the various pressures.

Pressures (mm.)	Per cent adsorbed air (removed)	Pressures (mm.)	Per cent adsorbed air (removed)
404.7	1.61	29.1	4.09
307.8	2.21	28.8	4.28
204.7	2.45	25.0	4.65
171.3	2.54	15.3	4.72
113.9	2.65	9.8	4.75
86.1	3.01	6.2	4.75
53.5	3.46	4.8	4.75
43.5	3.85	2.6	4.75
41.3	3.91	1.8	4.83

Conclusions

(1) The Toepler pump offers a convenient means of measuring adsorbed and mechanically-held gases in materials.

(2) The apparatus as used for work with clay slips proved its practicability and accuracy. Even the small amounts of air present in the slip were readily measurable.

(3) A curve has been given, showing the relation between decrease in pressure and amounts of air removed. The values obtained seem to indicate that there is little possibility of sufficient air being present in a clay slip to justify its removal in plant practice.

(4) There seems to be no marked break in the curve at the boiling pressures to indicate a marked effect of the boiling process on the amount of air removed.

(5) The work with this apparatus indicates that it could be used in determining adsorbed air in refractories, glass, and many other similar materials. Many metals release gases to the extent of 400 volumes at 500°C. These could be measured in this apparatus by fitting with a heater as shown in Fig. 1.

(6) The apparatus could be used to determine porosity of materials, and, no doubt, many other applications might be adapted from this.

(7) It was found that tap-water samples gave off volumes of air approxi-

mating an average of 2% of the volume of the sample at the boiling pressure at 25°C. This did not readily reabsorb on standing in contact with the water surface at 300 mm. pressure. From this we might conclude that only 2.8% of the removed air in this case had been held by the clay particles.

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BLISTERING PHENOMENA IN THE ENAMELING OF CAST IRON[1]

By A. I. Krynitsky and W. N. Harrison

ABSTRACT

Physical defects in the castings, especially "sponginess," will cause blisters, as will also faulty composition or application of enamels. There are, however, differences in the tendencies of different sound castings to give blisters when enameled under identical conditions. The gases forming these blisters are CO and CO_2.

A gray iron casting acquires in freezing and cooling a very thin surface skin, or "microchill," of varying thickness and hardness. The data indicate that removal of this skin from sound castings eliminates blistering. During the enameling process the combined carbon of this skin tends to break down to a nascent, readily oxidizable form of carbon, which evolves CO and CO_2. There are probably two kinds of nonblistering iron, one in which little combined carbon is present at the surface, and another in which it is stabilized. Some irons are more prone to give the "microchilled" layer than others. During the early stages of enameling both blistering and nonblistering irons evolve gas, which is attributed to quick oxidation of submicroscopic graphite and which escapes before the enamel has fused to a retentive condition. Addition of graphitizing agents, such as silicon, may be beneficial, but the microchill is harder to avoid than the ordinary, or macrochill. Removal of the surface layer by deep sandblasting or "burning out" appears to be the most practical remedy for blistering of sound castings.

Introduction

This report deals with a continuation of an investigation on cast iron for enameling purposes.[2] Among the conclusions previously reported were: (*a*) that there is a definite difference in the tendency of different castings to produce blisters, (*b*) different heats of the same pig iron often have different blistering tendencies, and (*c*) the most prolific source of blisters from sound castings is confined to a thin surface layer, the removal of which causes a very definite improvement in blistering tendency.

The present article[3] describes the additional work which has been done and in some cases amplifies descriptions given in the previous report.

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[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce.

Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Enamel Division.) Received November 8, 1929.

[2] W. N. Harrison, C. M. Saeger, Jr., and A. I. Krynitsky, "Progress Report on Cast Iron for Enameling Purposes," *Jour. Amer. Ceram. Soc.*, **11** [8], 595 (1928).

[3] A full report of the investigation from the beginning, given in somewhat greater detail than this and especially than the previous report published in this *Journal* (see footnote 2), will appear in the Bureau of Standards, *Journal of Research*, under the title, "Blistering Phenomena in the Enameling of Cast Irons," by A. I. Krynitsky and W. N. Harrison.

The portion on the metallurgical phase of this investigation will appear in *Metals and Alloys* (419 Fourth Ave., New York City).

Experimental Work

Method of Making Enameling Test

Considerable difficulty was at first encountered in obtaining check results on the relative tendency of different sets of castings to blister. This hindrance was overcome by adopting a new type of enameling test, which was described in detail in the preceding report, and which for convenience is reviewed briefly here. Instead of using a single firing treatment, the test consisted of firing seven ground-coated specimens under a predetermined range of time periods, at a given temperature (875°C, 1605°F). The firing periods ranged from 3 to 17½ minutes, and the blistering tendency was judged according to the breadth of the range of treatments within which blister-free ware was produced. The operation of this system is best illustrated by reference to Fig. 3 (pp. 26 and 27).

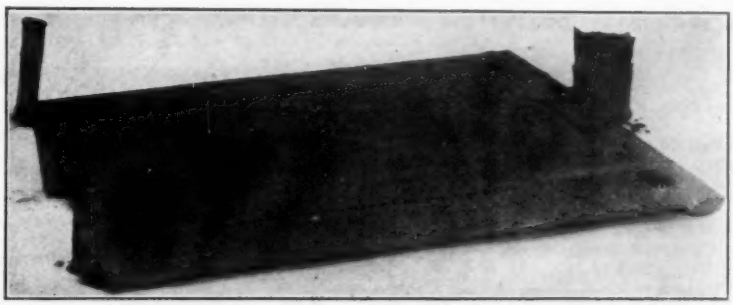

FIG. 1.—Cope side of plate 18½ x 18¼ x 3/16 inches with gate and risers, furnishing eighteen 3- x 6- x 3/16-inch specimens when cut.

Cover coats were all fired 8 minutes at 800°C (1470°F). One coat of wet-process cover enamel was used, the composition of which together with that of the ground coat, was given in the preceding article.

Each enameled specimen was given a rating by comparison with a set of selected specimens, as follows: (1) excellent, (2) satisfactory (probably passable by a commercial inspector), (3) slightly blistered (probably would be rejected), (4) badly blistered, and (5) very badly blistered.

Melting and Casting of Iron

During the early part of the work the melting was done in a cupola, but the later heats were all made in an indirect arc electric furnace of the rocking type, holding about 300 pounds of iron.

It was operated at 80 to 105 volts, 1100 to 1400 amperes (momentary readings). The average power input was 75 kw. On a representative heat of 325 lbs. iron, charged into a cold furnace, the metal was melted after 140 kw.-hr. had been used. Rocking of the furnace was then started.

After $2^1/_2$ hours with a total input of 190 kw.-hr., the metal was at 1480°C (2700°F). Unlike the small cupola, the electric furnace could be made to deliver the metal at any desired temperature, and was much more satisfactory to use on an experimental scale.

The method finally adopted for the preparation of specimens was to cast a relatively large plate, from which 18 specimens (3 x 6 x $^3/_{16}$ inch) could be cut, thus making it possible in most cases to avoid direct connection of a specimen with a gate. One of these cast plates is shown in Fig. 1.

Change of Composition on Remelting

The change in composition on repeated cupola melting and the much smaller change on electric melting is shown in Table I.

TABLE I

CHANGE IN COMPOSITION OF PIG IRON ON REPEATED MELTINGS IN CUPOLA AND ELECTRIC FURNACE

Iron	Melt	Heat	Carbon			Mn	P	S	Si
			Total (%)	Graphitic (%)	Combined (%)	(%)	(%)	(%)	(%)
R_1	Original pig		3.62	3.06	0.56	0.78	0.83	0.029	2.99
"	Cupola 1st	7	3.40	3.18	0.22	.69	.81	.048	2.82
"	" 2nd	12	3.25	2.84	0.41	.57	.84	.058	2.77
"	" 3rd	13	3.22	2.74	0.48	.44	.84	.086	2.69
R_1	Electric 1st	9	3.62	3.05	0.57	.73	.80	.026	2.90
"	" 1st	23	3.66	3.17	0.49	.73	.80	.023	2.77
"	" 2nd	11	3.76	3.28	0.48	.71	.79	.030	2.85
L_1	Original pig		3.81	3.15	0.66	.67	.46	.045	2.31
L_1	Cupola 1st	6	3.65	2.97	0.68	.56	.46	.050	2.16
"	" 1st	14	3.47	3.07	0.40	.57	.46	.076	2.24
"	" 2nd	15	3.51	2.74	0.77	.42	.46	.083	2.07
"	" 3rd	16	3.47	2.95	0.52	.33	.47	.095	1.92
"	" 4th	21	3.34	1.89	1.45	.24	.46	.108	1.70
"	" 5th	25	3.20	0.99	2.21	.18	.47	.125	1.51
L_1	Electric 1st	8	3.67	3.16	0.51	.62	.47	.048	2.32
"	" 1st	17	3.76	3.10	0.66	.63	.47	.038	2.19
"	" 2nd	10	3.97	3.34	0.63	.62	.44	.017	2.19

It will be noted that in cupola melting under the test conditions the total carbon, the manganese, and the silicon all drop from their percentages in the original pig due to oxidation, while the sulphur increases, due to picking up of sulphur from the coke.

In the electric furnace the total carbon, the silicon, and especially the manganese, change very little and there is no pick-up of sulphur. When attempting to control the composition for experimental purposes, it was therefore much easier to use the electric furnace than the cupola.

Heating Curve of Ground Coat

A sample of the ground coat used in the early part of this investigation was heated in a furnace with a thermocouple situated so as to indicate the

temperature of the enamel itself. By measuring the time-lag for definite temperature increments it was possible to tell at what temperature reaction took place. The results of this experiment are shown in Fig. 2. Apparently two endothermic reactions took place between 800°C and 950°C (1470 to 1740°F) in this particular ground coat. While no ultimate relationship of this curve with blistering has been established, it was considered of sufficient interest to include in the report.

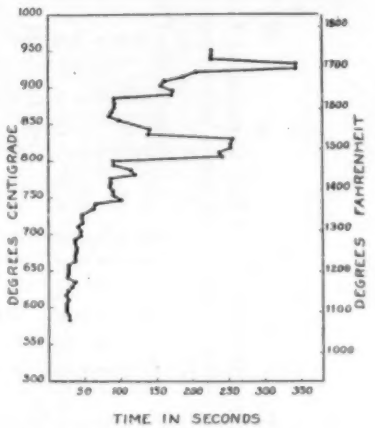

FIG. 2.—Inverse rate heating curve of the vitreous enamel ground coat powder RG–1 (+ 15% clay). The curve shows the time required to raise the temperature of this material a certain number of degrees at different temperatures.

Continuity of Ground Coat

A suggested explanation for some erratic results obtained early in the work was that perhaps the ground coat failed to cover the iron in spots and that blisters resulted from contact of the cover coat with those bare spots. Specimens to which the ground coat had been applied were tested by means of the "ferroxyl indicator"[4] for continuity of coating. A wall of plasticine (modeling clay) was built around the edges to hold the solution, in which two copper wires were immersed as a possible means of accelerating the action. Any exposed spot of iron was made evident by a blue precipitate which was held in place due to the gelatinous consistency developed by the indicator solution.

No ground-coated specimen was found which was free from bare spots. Since various lots of "nonblistering" iron showed no blisters, it was obvious that blisters need not result from contact of the cover coat at bare spots and the lack of continuity of the ground coat was, therefore, eliminated from consideration as a source of blisters.

Compositions of Pig Irons Used

The irons, R_1 and L_1, used in the early experiments, having been nearly exhausted, similar northern irons, R_2 (slightly blistering) and L_2 (strongly blistering) were obtained from the same sources as before. Southern iron, and southern charcoal pig irons were also obtained for comparison.

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[4] C. T. Thomas and W. Blum, "The Protective Value of Nickel Plating," *Trans. Amer. Electrochem. Soc.*, **48**, 76 (1925).

TABLE III

RESULTS OF COÖPERATIVE ENAMELING TESTS CARRIED OUT AT THE BUREAU AND IN TWO COMMERCIAL LABORATORIES

Enameling procedure	Ratings of specimens having ground coats fired for different periods in minutes														
	3	5	7½	10	12½	15	17½	Av.	3	5	7½	10	12½	15	17½	Av.
	Iron L_2 (Heat 1–55)								Iron L_2 (Heat 2–55)							
Elec. fur., Bur. Stand.	5	3	5	5	5	5	5	4.7	5	2	5	5	5	5	5	4.6
Gas fur., " "	5	5	4	5	5	5	5	4.9	3	2	3	5	5	5	5	4.0
Gas fur., Commercial Lab., No. 1	4	4	5	5	5	5	5	4.7	5	4	5	5	5	5	5	4.9
Elec. fur., Commercial Lab., No. 2	5	4	5	5	5	5	4	4.7	4	4	3	5	5	5	5	4.4
Av. grading	4.8	4.0	4.8	5.0	5.0	5.0	4.8	4.8	4.3	3.0	4.0	5.0	5.0	5.0	5.0	4.5
	Iron L_2 (Heat 3–55)								Iron L_2 (Heat 4–55)							
Elec. fur., Bur. Stand.	3	3	2	5	5	5	5	4.0	5	2	3	4	1	2	4	3.0
Gas fur., " "	4	1	2	5	5	5	5	3.9	5	2	1	3	4	3	4	3.1
Gas fur., Commercial Lab., No. 1	3	4	5	5	5	5	5	4.6	2	3	3	4	5	4	3	3.4
Elec. fur., " " No. 2	3	2	3	3	4	4	4	3.3	3	3	2	3	3	2	3	2.7
Av. grading	3.3	2.5	3.0	4.5	4.8	4.8	4.8	4.0	3.8	2.5	2.3	3.5	3.3	2.8	3.5	3.1
															Grand average of all:	4.1
	Iron R_2 (Heat 1–56)								Iron R_2 (Heat 2–56)							
Elec. fur., Bur. Stand.	5	4	5	5	5	5	5	4.8	4	1	2	2	3	1	1	2.0
Gas fur., " "	2	2	2	3	2	3	4	2.6	1	1	2	2	1	3	3	1.8
Gas fur., Commercial Lab., No. 1	4	4	5	5	5	3		4.3	2	3	3	4	3		3	3.0
Elec. fur., " " No. 2	5	4	3	4	5	5	3	4.1	5	1	2	3	3	3	3	2.8
Av. grading	4.0	3.5	3.8	4.3	4.3	4.0	4.0	3.9	3.0	1.5	2.3	2.8	2.5	2.3	2.5	2.4
	Iron R_2 (Heat 3–56)								Iron R_2 (Heat 4–56)							
Elec. fur., Bur. Stand.	4	1	4	3	3	3	1	2.7	5	5	4	5	3	3	4	4.1
Gas fur., " "	1	1	2	2	2	3	3	2.0	1	2	3	1	2	4	4	2.4
Gas fur., Commercial Lab., No. 1	2	2	3	3	3	3	3	2.7	3	4	5	5	5	5	5	4.6
Elec. fur., " " No. 2	3	1	2	3	3	2	1	2.1	4	2	2	4	5	4	5	3.7
Av. grading	2.5	1.3	2.8	2.8	2.8	2.8	2.0	2.4	3.3	3.3	3.5	3.8	3.8	4.0	4.5	3.7
															Grand average of all:	3.1

	Ratings of specimens baked at 500°C for 8 minutes with enamel on before firing															
	Ground coat	Cover coat	Ground and cover coats	Ground coat	Cover coat	Ground and cover coats	Ground coat	Cover coat	Ground and cover coats	Ground coat	Cover coat	Ground and cover coats	Ground coat	Cover coat	Ground and cover coats	Grand average
	Iron L_2 (Heat 1–55)			Iron L_2 (Heat 2–55)			Iron L_2 (Heat 3–55)			Iron L_2 (Heat 4–55)			Av. rating			
Baked in electric furnace; fired in gas furnace Bur. Stand.	1	3	3	2	1	2	1	2	1	1	1	1	1.3	1.8	1.8	
Baked and fired in gas furnace Commercial Lab., No. 1	5	5	5	5	5	5	5	5	5	4	3	4	4.8	4.5	4.8	
Baked and fired in electric furnace; Commercial Lab., No. 2	3	3	3	2	2	3	4	3	3	3	2	3	3.0	2.5	3.0	
												Grand av.	3.0	2.9	3.2	3.0*
	Iron R_2 (Heat 1–56)			Iron R_2 (Heat 2–56)			Iron R_2 (Heat 3–56)			Iron R_2 (Heat 4–56)						
Baked in electric furnace; fired in gas furnace Bur. Stand.	2	3	1	1	1	1	1	2	3	1	1	2	1.3	1.8	1.8	
Baked and fired in gas furnace Commercial Lab., No. 1	4	3	3	3	1	1	3	3	2	4	3	3	3.5	2.5	2.3	
Baked and fired in electric furnace, Commercial Lab., No. 2	3	2	3	3	1	2	3	1	3	4	2	3	3.3	1.5	2.8	
												Grand av.	2.7	1.9	2.3	2.3†

* This average rating of 3.0 is to be compared with average of iron L_2, unbaked, at $7\frac{1}{2}$ minutes only (3.5).
† " " " " 2.3 " (3.1).

The composition of all of the pig irons used is shown in Table II.

TABLE II

COMPOSITION OF PIG IRONS USED IN ENAMELING TESTS

Designation of irons	Character	Total C (%)	Graphitic C (%)	Combined C (%)	Mn (%)	P (%)	S (%)	Si (%)
Southern charcoal	Weakly blistering	3.82	3.40	0.42	0.17	0.51	0.024	1.75
Southern	" "	3.55	3.15	.40	.24	.82	.021	2.73
R_1	" "	3.62	3.06	.56	.78	.83	.029	2.99
R_2	" "	3.61	2.96	.65	.68	.78	.045	2.66
L_1	Blistering	3.81	3.15	.66	.67	.46	.045	2.31
L_2	"	3.73	3.14	.59	.78	.50	.090	2.55

(See page 33 for content of other elements)

Data on Coöperative Experiments

Mention was made in the progress report of a series of tests carried out on a relatively large scale, both at the Bureau and in the laboratories of two coöperating plants, using four heats each of a strongly-blistering iron (L_2) and a weakly-blistering iron (R_2). The results of these experiments are of such importance that they are referred to at intervals throughout this report, and a complete tabulation of them is given in Table III. The results of analyses of the different heats of iron are given in Table IV. These tabulations, and the following discussion, will serve to supplement the brief description given in the progress report.

TABLE IV

RESULTS OF ANALYSES OF DIFFERENT HEATS OF L_2 AND R_2 IRONS

Heat No.	Iron	Approximate pouring temperatures °C	Composition: Total C (%)	Graphitic C (%)	Combined C (%)	Mn (%)	P (%)	S (%)	Si (%)	Cr (%)
1–55	L_2	1410–1388	3.40	2.93	0.47	0.72	0.555	0.035	2.37	0.04
2–55	L_2	1380	3.54	3.06	.48				2.34	
3–55	L_2	1390	3.46	2.94	.52				2.39	
4–55	L_2	1400	3.36	3.10	.26	.72	.515	.039	2.30	.04
1–56	R_2	1398	3.13	2.94	.19				2.53	
2–56	R_2	1398	3.48	3.10	.38	.61	.790	.027	2.22	.03
3–56	R_2	1388	3.39	3.11	.28				2.51	
4–56	R_2	1380–1350	3.45	3.08	.37				2.45	.04

Two factors which are very important from the standpoint of this investigation stand out clearly from the results of these coöperative tests. First, there is a difference in the tendencies of different lots of iron to produce blisters when enameled under uniform conditions. Second, different heats of the same pig iron may vary in their blistering tendencies just as definitely as heats from different pig irons do. Table III shows that there are four heats of each iron and four sets of testing conditions for each heat (two commercial laboratories and two different types of furnaces at the

Bureau). The average ratings under these four sets of conditions agreed very well in placing the different sets of castings in order of blistering tendency. Thus, for the four heats of iron L_2, heat 4–55 was first (in order of increasing blistering tendency) in all four cases. Heat 3–55 was second in all four cases. Heat 2–55 was third in three out of four cases, and fourth in the remaining case. Heat 1–55 was placed at the bottom of the list (greatest blistering tendency) in three out of four cases, and next to the bottom in the other one case. For iron R_2 there was unanimous agreement that heats 2–56 and 3–56 are both better than either 1–56 or 4–56. The former two heats were evenly divided between first and second places. Heat 4–56 received third place in three out of four cases, and fourth place in the remaining case. Heat 1–56 received the poorest rating in three out of four cases, and next to the poorest in the other case. The average ratings (Table III) showed that heat 4–55 has so much less blistering tendency than the other three heats of iron L_2 that it may be classed separately from them. Likewise, heat 1–56 has considerably more blistering tendency on the average than the other three heats of iron R_2. The superiority of iron R_2 over L_2, with respect to blistering tendency, is quite marked in the remaining six heats.

Commercial laboratory No. 2 as a rule produced specimens not so badly blistered as laboratory No. 1. In this connection it is significant (in view of the results reported later) that laboratory No. 2 used a commercial sandblasting outfit with 90 pounds air pressure (firing in an electric furnace) while laboratory No. 1 used a laboratory sandblast at a considerably lower air pressure (firing in a gas furnace).

The comparative ratings of individual specimens were often inconsistent. Thus, for heat 3–55 at 5 minutes firing of the ground coat, the ratings were 1, 2, 3, and 4, respectively, in the four tests.

The results obtained with the baking tests, *i.e.*, tests in which specimens coated with raw enamel were heated for 5 minutes at 500°C (930°F) before placing in the enameling furnace, varied according to the laboratory in which the tests were made. Since in the baking tests the ground coats were all fired $7\frac{1}{2}$ minutes, it seems logical to compare the baked specimens with only those unbaked ones which had the same firing treatment. The data in Table III, when analyzed in this way, show that in the Bureau tests baking was distinctly beneficial, and that baking of the ground coat only caused greater improvement than any other baking procedure. Thus, six out of eight specimens having only the ground coat baked received the highest rating, and the other two were next in rank. The average rating of these eight specimens was 1.3 while the ratings of those not baked averaged 3.1, and the rating of those baked according to the other procedures averaged 1.8. In commercial plant No. 2, baking also tended to reduce blistering, though to a lesser extent than at the

Bureau. In this case baking only the cover coat was the procedure which was beneficial, the other procedures appearing in some cases to be ineffective or somewhat detrimental. Commercial laboratory No. 1 obtained uniformly unsatisfactory results with the L_2 iron, baked or unbaked, but found a considerable improvement in the R_2 iron when baked. The results of some additional tests on baking which were carried out at the Bureau but not duplicated in the two coöperating laboratories are given in Table V.

TABLE V

RESULTS OF ENAMELING TESTS ON HEAT NO. 44, IRON L_2 AFTER BAKING

(Ratings of Specimens Having Ground Coats Fired for Different Periods)

	3 min.	5 min.	7½ min.	10 min.	12½ min.
Ground and cover coats baked 8 min. at 500°C (930°F)	3	3	2	3	3
	3	4	4	4	2
		3, 1	(duplicate)		
Av.	3	2.7	3	3.5	2.5
	5	4	3	4	4
	5	4	4	5	5
Not baked		2, 4	(duplicate)		
Av.	5	3.5	3.5	4.5	4.5

Study of Surface Layers of Castings with Respect to Blistering Tendency

In the progress report it was clearly illustrated how removal of the surface layers of the blistering irons used in this work markedly reduced blistering, even when the removed layer was extremely thin.[5] The dependence of the amount of blistering on the sandblast treatment led to the adoption of a more carefully controlled blasting procedure. Ottawa silica sand (20- to 30-mesh) was delivered at 60 pounds pressure from a nozzle of 1 inch inside diameter, normal to the surface of the specimens placed 4 inches below for a period of 45 seconds. The specimens were moved horizontally during sandblasting, and when an occasional specimen having less than the usual 18-square inch surface was blasted, a proportionally shorter blasting period was used.

Additions of Softening Agents, also Phosphorus and Fused Sodium Carbonate

On the theory that a softer (lower combined carbon) iron might be less "blistering" and more susceptible to removal of the surface layer in an ordinary cleaning process, an attempt was made to improve iron L_2, the more strongly blistering one, by softening it. Since raising the silicon or nickel contents would tend to produce this result, ½% of each

[5] This, of course, applies to castings which are physically sound, as obviously no improvement would result from removal of the surface layer of a casting when the blistering is caused by sponginess or other physical defects.

TABLE VI

EFFECTS OF NICKEL AND SILICON ADDITIONS ON RATINGS OF IRON L_2 (ELECTRIC FURNACE MELTS)

Addition	Heat	Composition: Carbon Total C (%)	Carbon Graphitic C (%)	Carbon Combined C (%)	Mn (%)	P (%)	S (%)	Si (%)	Ni (%)	Standard enamel rating at firing time shown (minutes): 3½	5	7½	10	12½	15	17½
None	1-2-3-4-55	(See Table IV)								4.4	2.5	3.1	4.6	4.4	4.4	4.7*
None	61	3.26	2.78	0.48				2.12			2	3	3	3	3	3
½% Ni	57	3.25	3.14	0.11	0.73	0.52	0.043	2.27	0.51	2.0	2.0	2.3	2.3	3.0	3.3	4.0†
½% Ni	63	Not analyzed									2	3	3	4	3	5
½% Si	60	3.25	2.83	0.42				2.56			1	2	3	4	3	3

* Average of Bureau of Standards tests in Table III for all four heats without baking.

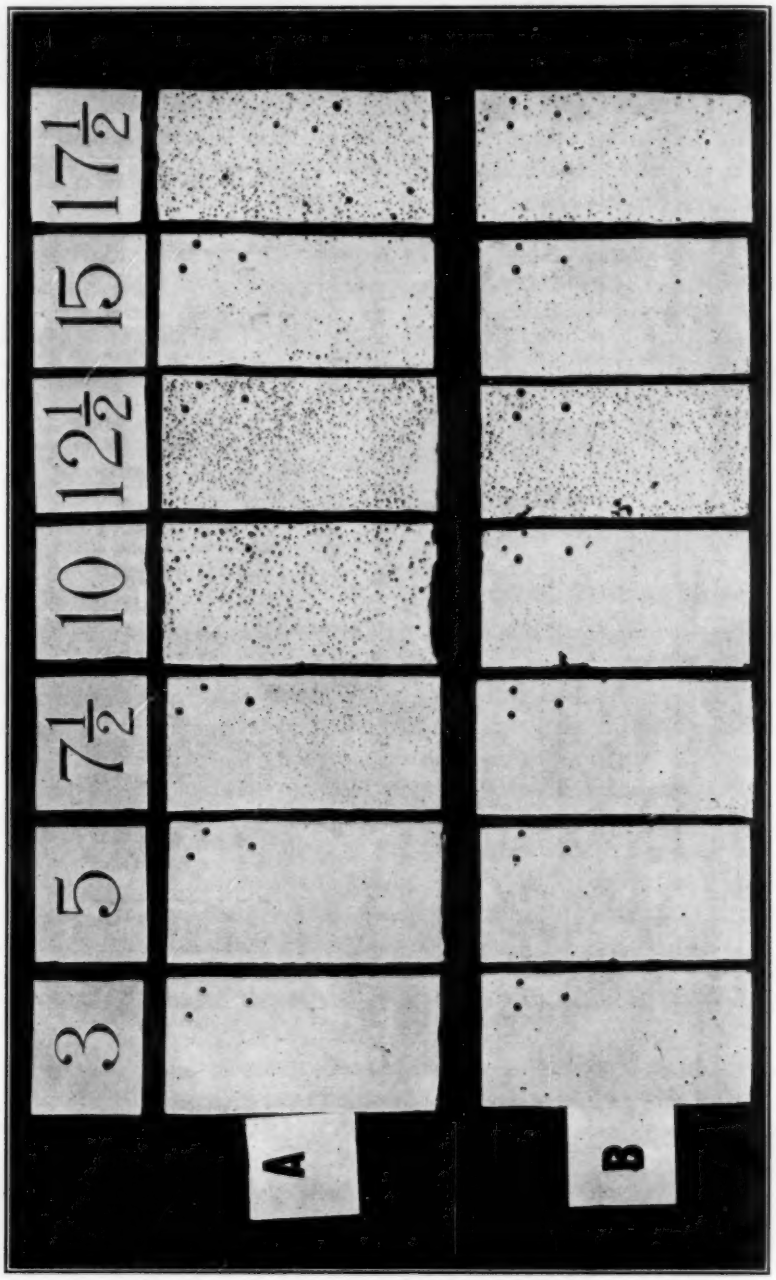
† Average of three sets of tests at Bureau.

TABLE VII

TESTS OF IRON L_2 WITH AND WITHOUT ADDITIONS OF SILICON (ELECTRIC FURNACE MELTS)

Plate No.	Iron	Approx. pouring temp. °C	Composition: Total C (%)	Graphitic C (%)	Combined C (%)	Si[1] (%)	Standard enamel ratings at firing periods shown in minutes: 3½	5	7½	10	12½	15	17½	Av.
1-73	L_2	1400	3.54	2.94	0.60	2.35	2½	2	4	5	4	4	5	3.8
			3.52	3.05	.47	2.30								
2-73	L_2	1230					1	2½	4	5	5	4½	5	3.9
3-73	L_2 + ½% Si	1400	3.54	3.11	.43	2.49	3	2½	3½	4	5	4	5	3.9
			3.53	3.20	.33	2.53								
4-73	L_2 + ¾% Si	1400	3.41	3.01	.40	2.64	3½	2	2	3½	4	5	3	3.3
			3.49	3.01	.48	2.65								
5-73	L_2 + 1% Si	1400	3.48	2.99	.49	2.91	2½	2½	2	3	3	3	4½	2.9
			3.48	3.03	.45	2.93								
6-73	L_2 + 1% Si	1230					2½	2	2	3	3	3	4½	2.9

[1] The amounts of silicon found by analysis did not increase correspondingly with the amounts added, because a portion of the silicon was burned away.


3
5
7½
10
12½
15
17½
A
B

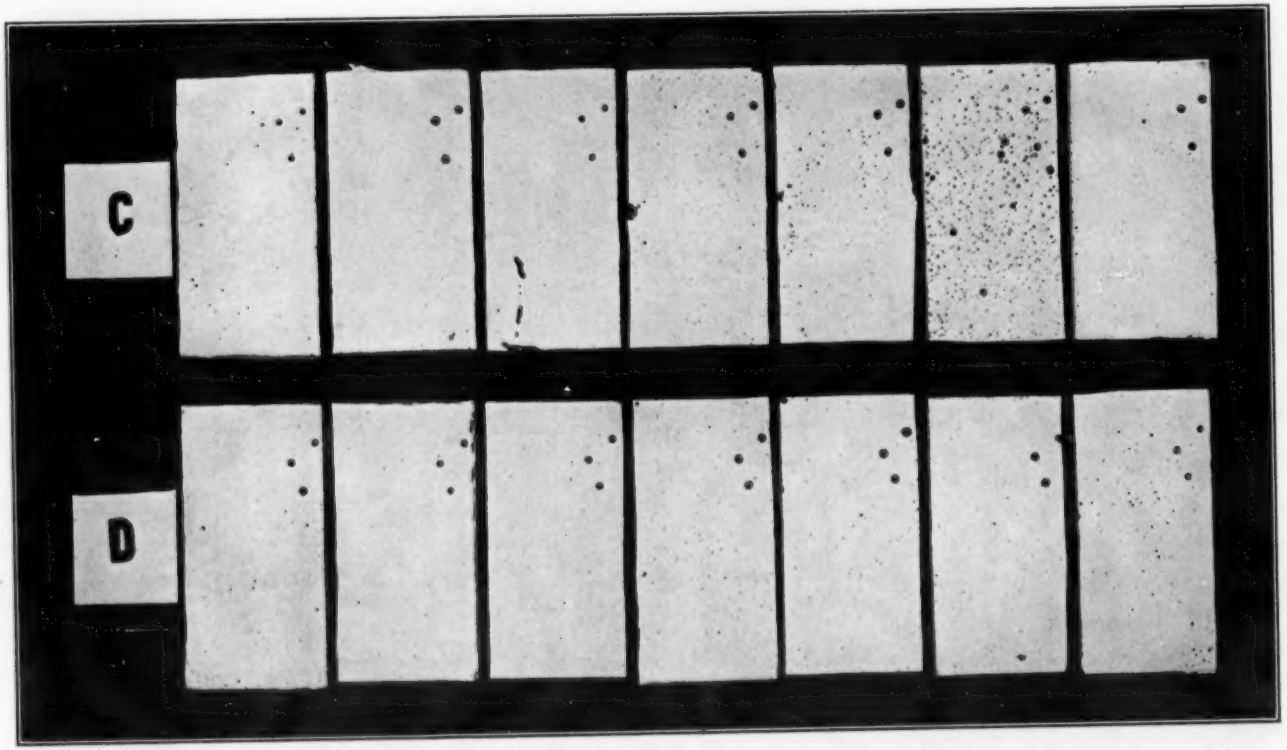


FIG. 3.—Effect of silicon additions on blistering tendency. A, 2.32% Si; B, 2.51% Si; C, 2.65% Si; and D, 2.92% Si; the average of two determinations is given in Table VII. The numbers indicate minutes of firing ground coat at 875°C (1605°F); cover coats all fired 8 minutes at 800°C (1470°F).

element was added separately and the "range" method of enameling test, (*i.e.*, the use of a range of firing treatments) was applied (see Table VI).

The results, compared with those of Table III over the important firing range of 5 to 10 minutes, would appear promising since none of the softened irons were rated worse than a grade 3 specimen over this range, while in Table III one-half of the L_2 specimens tested at the Bureau over this firing range were given poorer grades. In the comparison heat, however, of L_2 (No. 61), made as a blank with this series, no specimens were rated worse than grade 3, so the evidence was inconclusive. Therefore, several further tests with additions of nickel, silicon, and aluminum were made. While no conclusive results were obtained in a limited number of experiments with ladle additions of $^1/_2\%$ and 2% nickel, or with 1% aluminum, promising results were obtained with silicon additions made in the furnace. Table VII and Fig. 3 show that there was a noticeable improvement in the enameling properties of the blistering iron L_2 with a higher silicon content, addition of this element being made in the furnace. While the variation in silicon content was evidently not sufficient to cause a marked change in the average amount of combined carbon throughout the castings, it is thought that this variation was large enough to affect the combined carbon present in the surface layer.

The phosphorus as well as the silicon contents of the strongly-blistering iron L_2 were increased in certain heats to correspond with the weakly-blistering iron R_2. Also, a few tests were carried out using fused sodium carbonate as a fluxing addition, but the results of these experiments did not indicate any marked improvement.

Study of Burned-In Molding Sand

There appeared to be a possibility that the condition responsible for blistering might be a layer of burned-in sand grains which had not been removed by sandblasting, although it seemed likely that such material would be inert. Hence, specimens of nonblistering iron were deeply sandblasted at one end and the amount of sandblasting was decreased sharply toward the other end, where burned-in sand grains were readily detected with a binocular microscope. These burned-in sand grains did not produce any blisters when the specimens were enameled.

In another test, molding sand was scattered over a deeply sandblasted specimen and the enamel applied as usual. This specimen did not blister. Hence, adhering sand, in itself, does not appear to be a direct cause of blistering, though a burned-in layer would retard the removal of the outside layer of metal during sandblasting.

Striking confirmatory evidence of this was obtained with a plate of blistering iron L_2 which had a firmly adhering scale of burned-in sand. This plate was sandblasted while being held at an angle to the sand stream

so that one end was sandblasted just enough to be visibly free from adhering sand, but not enough to remove the "microchilled layer." The blasting was progressively decreased as the other end was approached. A strip at the end was completely shielded from the blast. On enameling, the shielded strip was entirely free from blisters, although, of course, the adhesion of the enamel was not commercially satisfactory. The sandblasted area showed progressively increasing blistering as the metal surface was more completely exposed. This test also gave conclusive evidence that blistering is due to a surface reaction and not to the freezing of "occluded" gas in the metal itself, since the portion which was not sandblasted was as free to evolve such gas as that which was sandblasted.

Composition of Surface Layers

Since the surface layer involved is very thin and the surface of a casting is not perfectly smooth, any attempt to mill off the outside layer for chemical examination will result in contamination of it with underlying material. A comparison, however, of the results of chemical analysis of the surface and of the body of the casting would appear to give useful indications. Heat 2–55 of iron L_2 with an average blistering index (Table III) of 4.5, *i.e.*, badly blistering, and heat 3–56 of iron R_2 with an average index of 2.4 were thus compared. The data appear in Table VIII.

TABLE VIII

CHEMICAL COMPOSITION OF SURFACE LAYER AND INTERIOR OF CAST PLATES OF IRONS L_2 AND R_2

	L_2 Heat 2–55 (badly blistering)		R_2 Heat 3–56 (weakly blistering)	
Elements	Outside layer 0.003 in. thick	Comparison layer (0.01 in. thick) several hundredths inch beneath the surface	Outside layer 0.003 in. thick	Comparison layer (0.01 in. thick) several hundredths inch beneath the surface
Total C	2.71	3.54	2.84	3.31
[Combined C]	[0.45]	[0.34]	[0.42]	[0.27]
[Graphitic C]	[2.26]	[3.20]	[2.42]	[3.04]
Manganese	0.61	0.73	0.45	0.61
Phorphorus	0.435	0.500	0.605	0.835
Sulphur	0.044	0.037	0.031	0.022
Silicon	2.42	2.63	2.33	2.46
Nitrogen	0.0033	less than 0.0005	0.0015	less than 0.0005
Total	6.22	7.44	6.26	7.24
Iron by difference	93.78	92.56	93.74	92.76

It is seen that in both cases, there is at the surface less total carbon, manganese, phorphorus, and silicon, but more combined carbon and sulphur. That is, the surface skin seems to be higher in iron than the interior, which segregation is to be expected.

The increase in combined carbon appears especially significant since that will obviously accompany the presence of a hard surface layer, which is difficult to remove by sandblasting. There seems, therefore, to be a

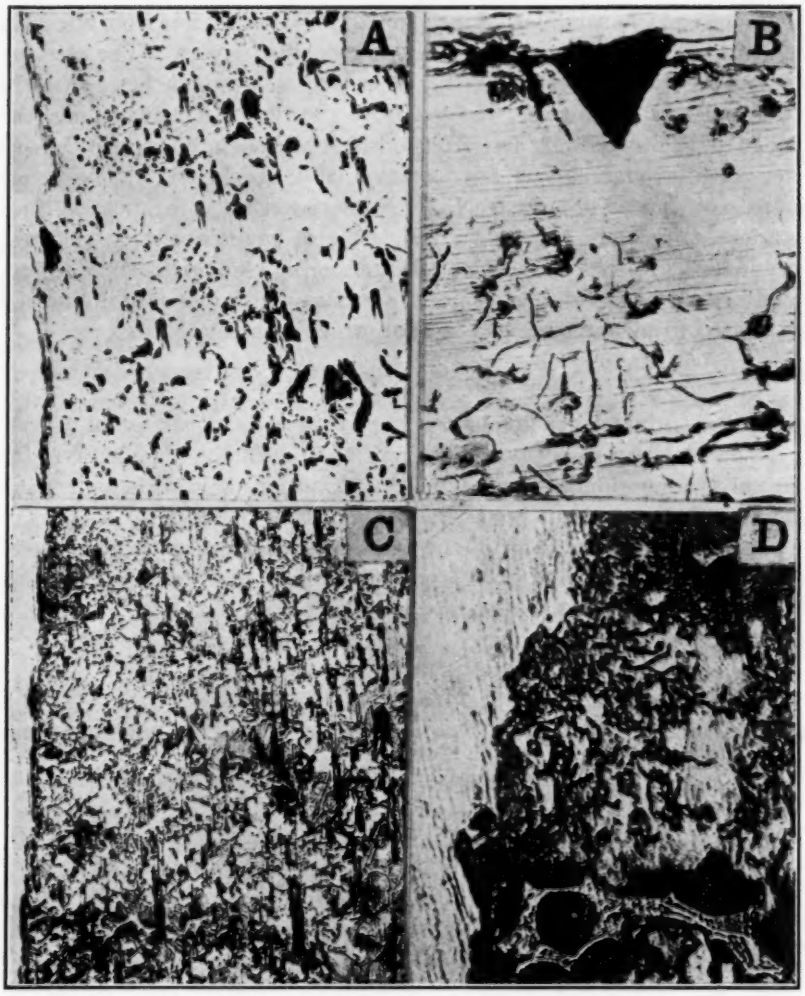


FIG. 4.—Iron R_2, heat 3–56. Cross-sectional views of surface layer (drag side) of castings, the composition of which, as shown by chemical analysis, is given in Table XV. Surface of iron is vertical at left side of A, C and D, and horizontal at top of B. (Specimens not enameled were nickel and copper plated before sectioning.) A, polished, × 100; B, polished, × 500; C, etched in 5% picric acid, × 100; D, etched in 5% picric acid, × 500.

"microchilled" surface layer ("micro" refers here to the thickness of the chilled layer), which is apparently not necessarily controlled by the propensity of the iron to chill in the ordinary sense of giving a visibly thick layer of white iron on rapid cooling, and which may be different in its nature from an ordinary chilled layer.

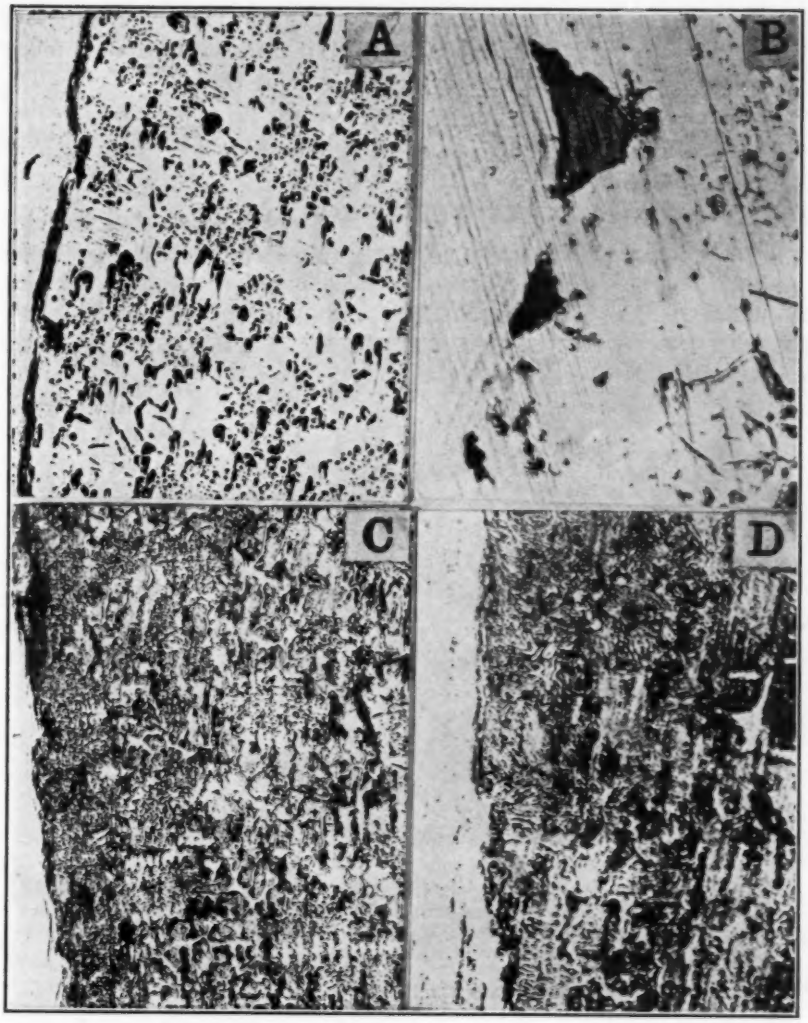


FIG. 5.—Iron L_2, heat 2–55. Cross-sectional views of surface layer (drag side) of castings, the composition of which, as shown by chemical analysis, is given in Table XV. A, polished, × 100; B, polished, × 500; C, etched in 5% picric acid, × 100; D, etched in 5% picric acid, × 500. (Surface of specimens vertical at left side of these and all following micrographs.)

Microscopic Examination of "Microchilled" Layer

The difference in composition at the extreme surface is probably greater than is shown by the chemical analysis, since in machining off the surface layer, thin as it was, doubtless some material more nearly approaching

the body of the casting in composition was included. The microstructure of the surface of iron R_3, heat 3–56 (Fig. 4D), indicates it to contain much less combined carbon than the surface of iron I_{a2}, heat 2–55 (Fig. 5D). The surface of the best heat (4–55) of iron I_{a2} (Fig. 6) appears to be more completely broken up into ferrite and graphite than is the case of heat 2–55.

Effect of Nitrogen

The nitrogen content (Table VIII) of the thin surface layer being higher

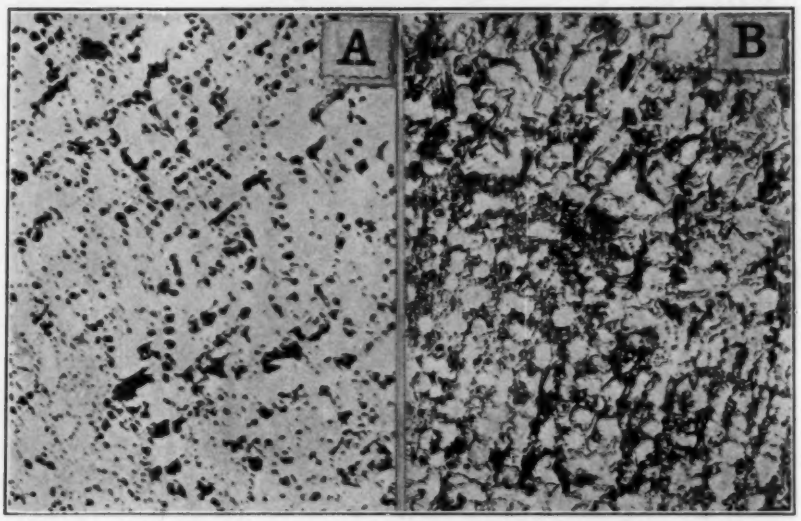


FIG. 6.—Iron I_{a2}, heat 4–55. Cross-sectional views of surface layer at drag side of casting. This heat was less strongly blistering than the companion heats (1–55, 2–55, and 3–55) of iron I_{a2}. A, polished, × 100; B, etched in picric acid, × 100.

than that of the body interior calls for attention, especially as the strongly-blistering iron shows double the amount of nitrogen in the surface than the weakly-blistering one does. The nitrogen might play a part in two different ways. If it is present as iron nitride, which decomposes at or below enameling temperatures, it constitutes a possible source of gas bubbles. If, on the other hand, it is present as chromium or titanium nitrides, a hard skin would tend to form as in the case of special steels containing aluminum and chromium, heated in an atmosphere of ammonia, and thus sandblasting might be seriously retarded.

That nitrides probably play no direct part in the formation of blisters

was indicated by the following test: half of the drag side of strips 6 x $^3/_4$ x $^3/_{16}$ inch of R_2 iron, heat 3–56, were slightly machined and both drag and cope sides were given the standard sandblasting. These strips then were heated to 500°C (930°F) in a stream of ammonia for periods of one, two, and five hours according to the usual method employed in forming nitride coatings. The nitrided strips were then very lightly sandblasted and the cope side of each strip was machined off to give a sample for chemical analyses for nitrogen, the layer removed being 0.003 inch thick. Analysis showed the nitrogen content of the surface layer of the three to be 0.05%, 0.08%, and 1.0%, respectively. On enameling these specimens on the drag side, in the usual fashion, there was no sign of blisters either on the machined area or on the nonmachined area, though both contained nitrogen in far higher proportions than found on the surface layer of the blistering iron.

There is some evidence that the minute amount of nitrogen introduced in melting steel, and presumably in cast iron, may be more stable than the nitride formed on the surface by heating in ammonia gas, and hence might decompose at a different temperature, perhaps just a temperature at which the gas would be caught in the enamel, so that the test may not entirely exclude the possibility that nitrogen causes blistering.

Spectroscopic and Chemical Analyses for Elements Not Usually Reported

There is a possibility that traces of elements that would form hard nitrides might play a part in the formation of a hard skin. Spectroscopic analysis of the strongly-blistering iron, L_1, and the weakly-blistering iron, R_1, made early in the investigation, showed nickel to be absent, but titanium, vanadium, chromium, traces of aluminum, and of course, copper, to be present in addition to the elements usually reported in chemical analysis of cast iron.

Chemical analysis for these elements and for total oxygen and hydrogen gave the following results:

Designation of irons	Character	Cu (%)	Ti (%)	Cr (%)	V (%)	Al (%)	O (%)	H (%)
L_1	Strongly blistering	0.07	0.08	0.025	0.030	(a)	0.002	0.0007
R_1	Weakly blistering	.03	.15	.010	.025	(a)	.004	.0005

(a) Less than 0.005%.

Since copper is present in all pig iron, and is not a carbide- or nitride-forming element, it can hardly be suspected of having anything to do with blistering. Vanadium and aluminum are essentially identical in the two irons. Titanium, a nitride-forming element, might be suspected,

but the fact that the strongly-blistering iron contains only half as much as the weakly-blistering one seems to remove titanium from suspicion.

Gilmore[6] points out that aluminum and titanium act like silicon in favoring the softening of iron by the precipitation of graphite, and states that both vanadium and chromium assist carbon in remaining in the combined form, a quarter of one per cent of chromium holding 0.80% carbon in the combined form after a malleableizing anneal.

Effect of Chromium

Chromium was present in the strongly-blistering iron, L_1, in appreciably larger amount than in the weakly-blistering, R_1. Since small amounts of chromium are known to increase the chill on cast iron and to interfere considerably with the malleableizing anneal of malleable cast iron, by tending to retain the carbon in the combined form, there is a possibility that even this slight difference in chromium content might favor the formation or retention of a surface layer higher in combined carbon, hence, harder and more difficult to remove in sandblasting.

To examine further the hypothesis that the chromium content might have a connection with the propensity toward blistering, the irons used in the latter part of the investigation were analyzed for chromium, with the results given in Table IX.

TABLE IX

CHROMIUM CONTENTS AND ENAMEL RATINGS OF CERTAIN HEATS OF IRON

Iron	Heat No.	Chromium (%)	Enamel rating (Table III)
L_2	1–55	0.04	4.8
L_2	4–55	.04	3.1
R_2	4–56	.04	3.7
R_2	2–56	.03	2.4
Southern charcoal	42	.03	(*a*)
Southern	41	.10	(*a*)

(*a*) Ratings not comparable since irons were tested only at the Bureau.

It will be noted that the strongly-blistering iron L_2 and the worse heat (4–56) of the weakly-blistering iron R_2 contain slightly more chromium than the better heat (2–56) of R_2 or of the southern charcoal iron. While the difference is very slight it is in the direction of damage due to chromium.

Although the enamel rating obtained with southern iron is not comparable to the others, there is little doubt that it has as little blistering tendency as any iron studied. Yet it contains much more chromium than any of the others, so that the mere presence of chromium cannot be taken as the sole cause for blistering. This cannot be considered as entirely eliminating chromium from consideration, because the forma-

[6] L. E. Gilmore, "Effect of Various Elements on Malleable Cast Iron," *Trans. Amer. Foundrymen's Assn.*, **35**, 356 (1927).

tion of the microchilled layer is evidently a matter of delicate balance and the effect of chromium in irons of different composition as to other elements may not be the same.

To study the chromium problem more thoroughly an experiment was made to see whether addition of chromium to the weakly-blistering northern iron R_2 increased its propensity to blister. As may be seen from Table X, a noticeable increase in blistering accompanied the addition of 0.03% chromium, but the larger additions (0.05% and 0.10%) showed no effect.

TABLE X

ENAMELING TESTS OF IRONS R_2 AND L_2 WITHOUT AND WITH ADDITIONS OF CHROMIUM: ELECTRIC FURNACE MELTS

Plate No.	Irons	Approximate pouring temp. (°C)	Standard enamel ratings at firing time shown in minutes: 3½	5	7½	10	12½	15	17½	Av.
1-71	R_2	1400	4	1	2	2	3	2	2½	2.4
2-71	R_2 + 0.03% Cr	"	4	2½	4	3	3	4	2½	3.3
3-71	R_2 + 0.05% Cr	"	4	1	1	2	2½	3	3	2.4
4-71	R_2 + 0.1% Cr	"	3½	1	2	2	3	2½	3	2.4
5-71	R_2	1390	3	2	3	2	3	3	3	2.7
6-71	R_2	1250	4	2½	2	3½	3½	2½	2	2.9
1-72	L_2	1400	2½	2½	2½	5	5	5	5	4.0
2-72	L_2 + 0.03% Cr	"	3	2½	2½	5	5	5	5	4.0
3-72	L_2 + 0.05% Cr	"	3	2½	2½	4	5	5	5	3.9
4-72	L_2 + 0.1% Cr	"	3	2½	2	5	5	5	5	4.0
5-72	L_2 tapped from furnace 14 min. after 1-72 was tapped	"	2½	2	2½	5	5	5	5	3.9
6-72	L_2 tapped from furnace 20 min. after tapping of 5-72	1320	3½	2½	5	4½	4½	5	5	4.3

Similar experiments were carried out with additions of chromium on the blistering iron L_2 with the purpose of stabilizing combined carbon of the surface layer of those castings. As is shown in Table X, chromium, in the quantities used, had practically no effect.

Erratic Behavior of Pig Iron

The erratic behavior of iron containing small amounts of chromium, commented on above, reminds one that many cases are known where inexplicable differences are found in the behavior of different lots or heats of cast iron that do not differ materially in composition as determined by ordinary chemical analysis. Sometimes this can be explained on the basis of a delicate balance among elements, *e.g.*, manganese and sulphur.

Piwowarsky[7] finds that the combined carbon content of gray-iron castings is affected by the temperature and duration of superheating of the melt. These factors also produce variations in the number and size of graphite nuclei upon which graphite will be precipitated on freezing.

[7] E. Piwowarsky, "Progress in the Production of High-Test Cast Irons," *Trans. Amer. Foundrymen's Assn.*, **34**, 914 (1926).

According to Hailstone's[8] experiments with a series of melts of almost identical analysis (3.25 to 3.31% carbon, 1.88 to 1.91% silicon, 0.092 to 0.097% sulphur, 0.26 to 0.27% manganese, 1.41 to 1.47% phosphorus), cast in green sand at temperatures ranging from about 1400°C to about 1265°C, the combined carbon dropped quite uniformly from 0.43 to 0.19% with decrease in pouring temperature, all conditions other than pouring temperature being held constant.

Study of Gases and Gas-Forming Elements

Oxygen Herty and Gaines,[9] found that pig iron tapped after a blast furnace "slip" may contain an excessive amount of suspended silica or silicates in a very fine state of subdivision, and that these, being difficult to reduce or flux out in steel making, give inferior steel.

It does not, however, appear likely that the presence or absence of such inclusions is directly responsible for the difference between blistering and nonblistering irons. If the suspended particles are not reduced by the carbon of the iron while it is molten, it is not likely that they will be reduced by it in the solid metal when heated only to enameling temperatures. Hence the evolution of CO from within the metal itself by reaction of inclusions during enameling is not a plausible explanation for blisters. The vacuum fusion method, moreover, for total oxygen determines the oxygen of silica and silicates, and hence will reflect the amount of inclusions present. As shown in the table on page 33; however, very little difference was found in the oxygen content of the two irons, the blistering iron containing even slightly less oxygen than the nonblistering one.

Hydrogen The difference in the hydrogen content of the two irons is within the precision of the analytical method, and since the amounts are so nearly the same, no indication is given that hydrogen is a factor.

Sulphur There is also a possibility that the gas might come from the oxidation of manganese sulphide or iron sulphide at the surface of the metal. To examine this hypothesis, sulphur determinations were made on the surface layer (0.003 in. thick) milled off of specimens of the strongly-blistering iron L_2, heat 2–55, after the usual sandblasting, and of other specimens of the same heat that had been put through the heating cycles of the enameling process under oxidizing conditions but without enamel. These cycles consisted of heating in air $12^1/_2$ minutes at 875°C (1605°F), cooling in air, and again heating in air 8 minutes at

[8] G. Hailstone, "An Investigation of Liquid Contraction in Cast Iron," Pt. 2, Iron and Steel Inst., Carnegie Scholarship Memoirs, p. 55, 1916.

[9] C. H. Herty, Jr. and J. M. Gaines, "Study of Unreduced Oxides in Pig Iron," *Jour. Amer. Inst. Mining & Met. Eng.*, Tech. Pub., No. 165.

800°C (1470°F). The amount of sulphur was not changed, being 0.050% in each case, and this indicated that there is no preferential oxidation of sulphur and that the blister-forming gas is probably not SO_2.

Gas in Blisters

If the composition of the gas in the blisters could be determined, one would have a very useful clue as to their source. On piercing the blisters of an enameled specimen under water, collecting and analyzing the gas, it was found to be air. Microscopic examination of the cross-sections of enamel coatings indicated that many of the internal bubbles were connected by channels with each other, and frequently with the air, so that whatever original gas they contained during the process of blistering, it may escape and be replaced by air (Fig. 7). Hence it was necessary to collect the gas formed in the act of blistering.

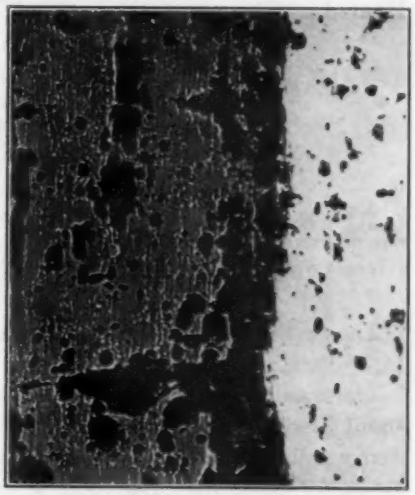


FIG. 7.—Southern iron, heat 41. Polished, ×100. Note interconnected channels in the enamel. No blisters were observed on this specimen. Ground coat fired 10 minutes at 875°C (1605°F) and cover coat 8 minutes at 800°C (1470°F).

Gas from Enamels

First of all a determination of whether the enamel alone and the iron alone evolved gas on heating was necessary.

That gas is evolved from the enamel alone is shown by the fact that the ground and cover coats of the standard enameling method (including the clay used) dried as in the enameling method, exposed to the air for 42 hours, dried again at 100°C for 1 hour, and finally heated to 500°C for 12 minutes, lost weight as follows:

	Total loss in weight up to	
	100°C	500°C
Ground coat	0.53%	2.24%
Cover coat	.07	0.62

Presumably the greater part of the loss at 500°C represents water of constitution of the clay, or at least firmly adsorbed moisture.

The ground coat and the clay used in it were then tested at enameling temperatures. The ground-coat slip (containing 15% clay on a dry basis) after first drying for an hour at 130 to 140°C (265 to 285°F) followed by

heating at 830°C (1525°F) for 8 minutes gave off 0.10% of CO_2. The clay alone gave off, beside an undetermined amount of moisture, 0.43% CO_2. Good agreement in both figures was obtained in duplicate determinations. Hence, the ground-coat slip gives off 0.06% CO_2 due to the clay and 0.04% CO_2 due to the frit itself. This amount of oxidized carbon, however, is of little importance as compared with amounts of similar gases from other sources, as will be shown later.

Gas from Iron Alone Heated in Nitrogen

There were then selected for the subsequent tests specimens of iron varying in their tendency toward blistering, as follows:

Iron	Heat	Average blistering index (See Table III)
L_1	1–55	4.8
L_2	2–55	4.5
L_4	4–55	3.1
R_2	2–56	2.4
Southern	41	1.8*

* The average rating (1.8) of southern iron, heat 41, poured at about 1400°C (2550°F) was obtained from tests at the Bureau only and hence is not comparable with other averages which included results obtained in several laboratories.

The first four specimens are northern irons. It is to be noted that iron L_2, 4–55, is much less blistering than the other heats of L_2, 55.

The total surface area of each sample (both sides and all edges) was about 5 square inches and each weighed about 50 grams. The samples were sandblasted in a manner corresponding to the usual method of preparation for enameling, placed in a furnace through which the desired gas was passing and heated. Any CO_2 and CO formed was collected in an analytical train and determined gravimetrically. In the first series, after drying for an hour at 150°C, the specimens were heated for 15 minutes in a stream of oxygen-free nitrogen at 875°C (1605°F). The results are given in Table XI.

TABLE XI

WEIGHT OF EVOLVED GASES FROM SPECIMENS HEATED IN OXYGEN-FREE NITROGEN

		Weight in grams of evolved gases per specimen			
Iron	Heat	CO_2	CO	H_2	CO_2 equivalent of total oxidized carbon
L_1	1–55	0.0040	0.0032	Nil	0.009
L_2	2–55	.0023	.0029	"	.007
L_4	4–55	.0029	.0035	"	.008
R_2	2–56	.0032	.0035	0.0001	.009
Southern	41	.0058	.0056	.0001	.015
		.0024	.0022		
		.0055	.0062		

Although the nitrogen was treated to remove the bulk of any oxygen present, the specimens after heating were darkened slightly, Southern Iron 41 being the darkest. The uniformity of the amount of equivalent

CO_2 from the L_2 and R_2 specimens indicates that the test does not differentiate between strongly- and weakly-blistering irons, and probably reflected merely the amount of air adsorbed on the metal surface or that entering the nitrogen-filled tube when the specimen is inserted, or possible traces of oxygen remaining in the nitrogen.

Gas from Iron Alone Heated in Air

In the next series of tests the specimens were heated in CO_2-free air instead of in nitrogen. The specimens, dried as before, were heated for 15 minutes at 875°C (1605°F).

While the carbon of the cast iron may burn to CO at the surface, the CO will, under the test conditions, be burnt almost entirely to CO_2, only traces of CO being collected in the analytical train. These traces were calculated back to equivalent CO_2. The complete results are given in Table XII.

TABLE XII

WEIGHT OF TOTAL CO_2 AND H EVOLVED FROM SPECIMENS HEATED IN CO_2-FREE AIR

Iron	Heat	CO_2 equivalent of total oxidized carbon (grams)	Weight H_2 (grams)
L_2	1–55	0.022	0.0001
L_2	2–55	.013	.0001
L_2	4–55	.008	.0001
R_2	2–56	.010	.0001
Southern	41	.017	.0001

Under the above conditions of heating, the most strongly-blistering castings produced the most CO_2, although the weakly-blistering southern iron produced nearly as large an amount of CO_2 as one of the strongly-blistering irons. The appearance of the oxidized surface, however, did show a consistent relation to the blistering tendency. The specimens of the 1–55 and 2–55 heats of iron L_2 had a decidedly rough surface. Heat 4–55 of L_2, which was a good example of weakly-blistering iron was decidedly smoother and had the same appearance as the specimen R_2 heat 2–56. The southern iron was still smoother, having a very smooth velvety appearance. In neither of the above two series of tests was there a decidedly detectable amount of hydrogen evolved.

Gas from Enamel-Coated Irons Heated in Nitrogen

In a third series of gas evolution tests, the iron specimens were coated on all sides with the standard ground coat, about 0.9 gram of wet ground coat being applied. The specimens were dried at 80 to 90°C for 40 minutes. They were then inserted into the hot furnace tube through which oxygen-free nitrogen was passing, and heated at 875°C (1605°F) for 20 minutes. The firing time was longer than in the regular enameling tests because of the smaller heat capacity of the furnace as compared with furnaces for regular enameling.

Specimens coated on one side only and fired for a shorter period in preliminary tests had the appearance of being underfired.

Since the ground coat contained clay with water of constitution, the gas passing from the tube was scrubbed free from water vapor by a drying tower. The equivalent of the total oxidized carbon evolved is shown in Table XIII. All figures are averages of two closely agreeing determinations.

TABLE XIII

GAS EVOLVED FROM CAST-IRON SPECIMENS COATED WITH GROUND ENAMEL AND HEATED IN NITROGEN

Iron	Heat	CO_2 equivalent of total oxidized carbon* grams	H_2 Weight in grams
L_2	1–55	0.008	nil
L_2	2–55	.008	"
L_2	4–55	.006	"
R_2	2–56	.006	"
Southern	41	.007	0.0001

* Of this CO_2 only 0.0005 g. was in all cases due to the ground coat alone.

It would be assumed that much of the air adsorbed on the surface of the iron specimens before spraying with ground coat would be displaced by the water of the ground coat, but the dry ground coat would presumably adsorb air. It is not possible to tell, therefore, whether the oxygen of the CO_2 comes from adsorbed air, air admitted in inserting the specimens into the tube, or from oxidation of the lead oxide of the ground coat. By comparing the four heats of northern irons, it might appear that the more strongly-blistering ones have the carbon at their surfaces in more readily oxidizable form, but the southern iron is out of line with this explanation.

The surface appearance of the specimens was again very characteristic,

TABLE XIV

GAS EVOLVED FROM CAST-IRON SPECIMENS COATED WITH GROUND ENAMEL AND HEATED IN AIR

Iron	Heat	CO_2 equivalent of total oxidized carbon (grams)	Weight H_2 (grams)
L_2	1–55	0.012	0.0001
L_2	2–55	.011	.0001
L_2	4–55	.009	nil
R_2	2–56	.010	"
Southern	41	.011	"

each pair of duplicate specimens agreeing closely in appearance. The specimens of iron L_2, heats 1–55 and 2–55 (the most strongly blistering ones), had the ground coat in very rough, pebbly form. Heats L_2, 4–55 and R_2, 2–56 (weakly blistering), had the coat in less rough form, while the weakly-blistering southern iron was very smoothly and evenly coated. The machined edges of all the specimens were smoothly and uniformly

coated with a glossy coat. The appearance of the specimens is shown in Fig. 8. The difference in surface roughness is more likely an effect of some condition leading to blistering rather than the cause, since it will be recalled that removing the surface of "blistering" iron by pickling was as efficacious as machining, though the pickled surface was extremely rough and the machined surface smooth. (See Progress Report, footnote 2.)

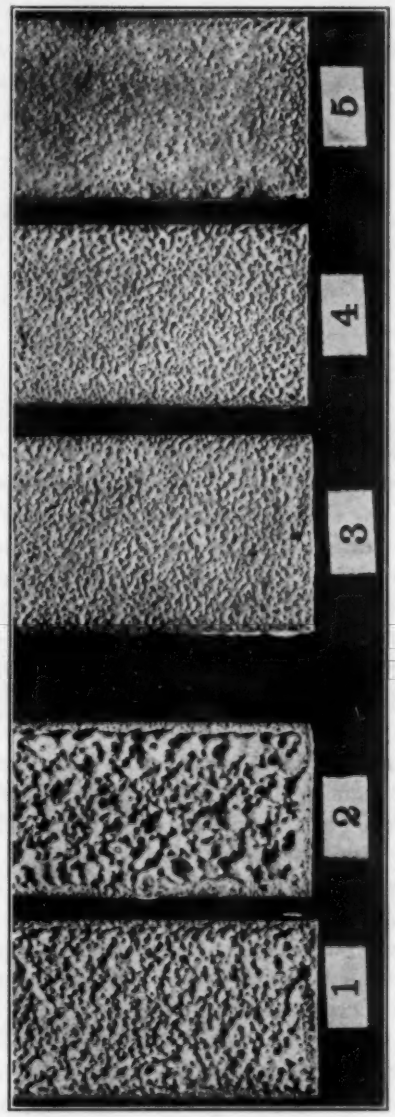


FIG. 8.—Surface appearance of specimens of strongly blistering and weakly blistering irons after firing the ground coats 20 minutes in nitrogen.

No. 1—Iron L_2, heat 1–55, strongly blistering.
No. 2—Iron L_2, heat 2–55, " "
No. 3—Iron L_2, heat 4–55, weakly " "
No. 4—Iron R_3, heat 2–56, " "
No. 5—Southern iron, heat 41, " "

Gas from Iron and Enamels Heated in Air In the fourth series of gas-evolution tests the iron specimens, coated with ground-coat enamel and dried as in the preceding series, were heated in CO_2-free air for 20 minutes at 875°C (1605°F). The CO_2 equivalents of the total oxidized carbon in this series were less for all the irons than in the series of uncoated irons heated in air, but remained in the same relative order as in the earlier series in air (see Table XIV).

The specimens from the series given in Table XIV were then coated with the standard cover-coat enamel in amounts equivalent to 23 grams of wet enamel slip per 18 square inches of surface, dried, and then heated as before in the tube furnace. This heating was for 12 minutes at 800°C (1470° F). Very small amounts of oxidized carbon were evolved during this heating and in quite the same amounts from all specimens, as shown in Table XV.

TABLE XV

GAS EVOLVED IN FIRING COVER COAT (SAME SPECIMENS AS IN TABLE XIV)

Iron	Heat	CO_2 equivalent of total oxidized carbon (grams)
L_2	1–55	0.003
L_2	2–55	.004
L_2	4–55	.004
R_2	2–56	.005
Southern	41	.004

Rate of Carbon Oxidation

The data obtained in all of the preceding tests indicate that carbon oxidized from the surface of the iron specimens is the chief source of the gas evolved during the firing of ground-coat enamels on cast iron. There is little or no evidence that either moisture or the oxide constituents of the enamel take an appreciable part in this oxidation of carbon from the surface of the iron. Oxygen of the air present in the enameling furnace is the oxidizing agent.

The foregoing experiments on gas evolution have been in reference only to the total amount of gas evolved during the firing period. It is apparent, however, that any rapid and large evolution of gas from a specimen in the early stages of firing on an enamel coat should have very little effect in forming blisters in the enamel. It is only after the enamel coat has been fused over and has completely covered the surface of the iron that gas evolution will cause blisters. Probably, only the gas evolution which continues well toward the close of the firing period produces blisters which are not healed by the fused enamel.

In order to throw light on the relative rates of gas evolution (that is, carbon oxidation) from irons at the various stages of the enamel firing period, the following experiment was made. Strips of the most typical strongly-blistering iron, 1–55, and of the three weakly-blistering irons, 2–56, 4–55, and Southern 41, were cleaned by the usual sandblast procedure, sprayed with the standard ground-coat enamel, dried and fired for varying periods of time up to a total of 20 minutes. The evolved oxides of carbon were determined in the manner previously described. The results are given in Table XVI and in Fig. 9.

From this figure it is evident that the amount of carbon oxidized and the

rate of oxidation were nearly the same for all the weakly-blistering irons and for the two series of tests with L_2, 1–55 (the strongly-blistering iron) up to a firing time of about 8 to 10 minutes.

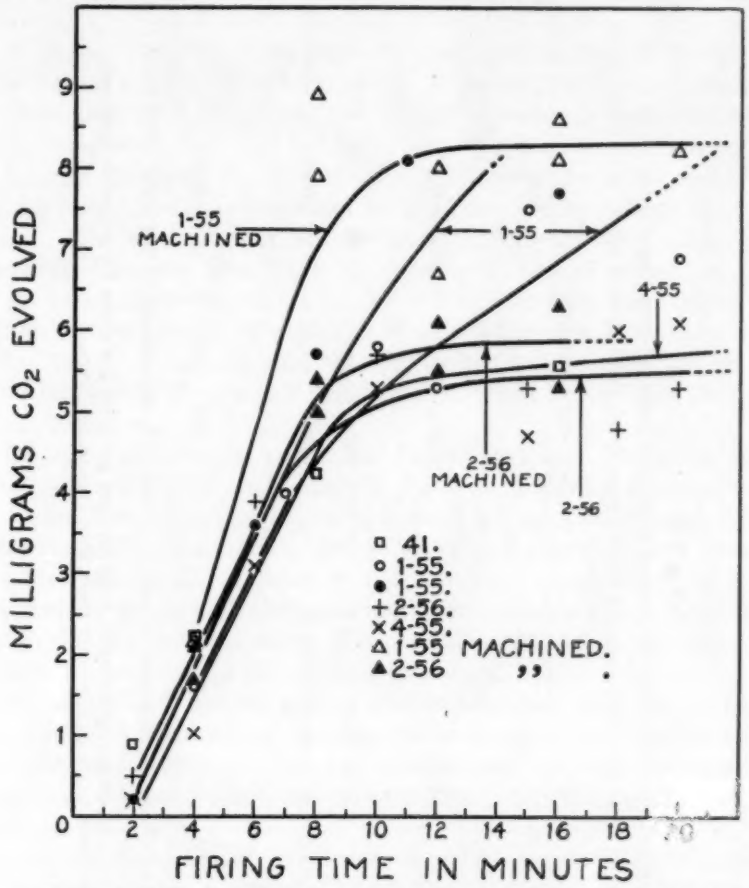


FIG. 9.—Weight of evolved CO + CO_2 (calculated to CO_2) plotted against firing periods. All specimens completely coated with ground coat and fired at 875°C (1605°F) in CO_2-free atmosphere. Each point represents one specimen and the corresponding analytical determination. L_2, 1–55 is a strongly blistering type of iron, while all of the others (including L_2, 1–55 machined) are weakly-blistering ones.

At the 8- to 10-minute firing period, however, the rate of carbon oxidation fell off very noticeably with all three[10] of the weakly-blistering irons

[10] A curve for southern iron 41 has not been drawn in Fig. 9 since for that iron only one value for CO_2 evolution was obtained between the 4-minute and the 16-minute firing periods. The points for this iron are given in the figure and they indicate that the curve for this iron would not differ greatly from those for the other weakly-blistering irons.

TABLE XVI

RELATIVE RATE OF OXIDATION OF CARBON FROM CAST IRONS DURING ENAMELING

(Irons cleaned in sand blast, sprayed on both sides with standard ground coat, dried, and heated at 875°C in CO_2-free air for the periods indicated.)

Designation of irons	Heat number	Character	Time of heating in minutes: Evolution of CO_2 in grams											
			2	4	6	7	8	10	11	12	15	16	18	20
L_2	1-55	Blistering	(*a*) (0.0002)		(0.0041)		(0.0065)		(0.0092)			(0.0087)		
			(*b*) .0002		0.0035		.0056		.0079			.0075		
I_2	1–55	"		0.0016		0.0040		0.0058		0.0053	0.0075			0.0069
I_2 (machined) (*c*)	1–55	"					.0079			.0067		.0086		.0082
I_3 (machined) (*c*)	1–55	"		.0022			.0089			.0080		.0081		
R_2	2–56	Weakly blistering	.0005	.0016	.0039			.0057			.0053		0.0048	.0053
R_2 (machined) (*c*)	2–56	" "		.0017			.0050			.0061		.0063		
R_2 (machined) (*c*)	2–56	" "		.0021			.0054			.0055		.0053		
I_4	4–55	" "	.0002	.0010	.0031			.0053			.0047		.0060	.0061
Southern	41	" "	.0008	.0023			.0043					.0056		

(*a*) The first set of specimens of 1–55 were $^7/_8$ inch wide instead of $^3/_4$ inch as in all other sets of this table. The values in parentheses are the actual values given by the $^7/_8$-inch specimen.

(*b*) These values are calculated for a $^3/_4$-inch wide specimen from the data given by the above $^7/_8$-inch wide specimen.

(*c*) These samples were machined down 0.003 inch on both sides, then treated as others.

and there was almost no evolution of gas (oxidized carbon) from these irons from 10 or 12 minutes to the 20-minute limit of the firing periods of this test. Gas evolution practically ceased over that portion of the enamel-firing period during which it would naturally be expected to cause blistering.

Of course, the whole cycle might be completed in a much shorter time in a furnace of greater heat capacity. It should, furthermore, be borne in mind that the first part of this period corresponds approximately to firing the ground coat, and the latter part to the additional heating that is necessary in firing the cover coat. It is during the latter part of this second period that it is important for gas evolution to be kept at a minimum. The two curves for the duplicate experiments with iron L_2, 1–55, the badly-blistering iron, show no decrease in rate of carbon oxidation at the point where the curves for the weakly-blistering irons flatten out, but indicate a continuing evolution of oxidized carbon practically to the end of the firing period used. Whether or not the curves flatten out here is not certain in the absence of additional points beyond the 20-minute firing period.

The question arose as to whether the curves which flatten out at the 8- to 10-minute period might begin to rise again if heating were continued, as, for instance, in the application of three or more coats of enamel. While these tests (Fig. 9) were not carried beyond 20 minutes in any case, the fact that blisters seldom occur on re-enameling castings, which may have blistered in the first enameling, seems to indicate that such a secondary rise in the gas-evolution curve, if it does take place, does not begin soon enough to give trouble in practical enameling.

The above data on the rate of carbon oxidation from the surface of enamel-coated cast-iron specimens all relate to iron cleaned by the normal sandblast procedure. It will be recalled that machining a 0.003-inch layer from the surface of a strongly-blistering iron strikingly reduced the tendency to blister.

If the cessation of oxidation of carbon relatively early in the firing period is the controlling characteristic of nonblistering irons, as is indicated by the curves for sandblast-cleaned irons in Fig. 9, then a blistering iron, from the surface of which a 0.003-inch layer has been machined, might be expected to behave similarly. Specimens of L_2, 1–55, and R_2, 2–56, were machined in this way, lightly sandblasted, and then treated exactly as the regularly sandblasted specimens of the same irons had been treated to determine the rate of carbon oxidation. The data on CO_2 evolution from the machined specimens are given in Table XVI and are plotted in Fig. 9.

These curves show that machining off the surface of iron R_2, 2–56, had no influence on the rate of carbon oxidation from its surface or on the

point at which oxidation of carbon ceases. Machining off the surface of L_2,1–55, however, noticeably increased the rate of carbon oxidation during the first 8 minutes of the firing period, but at the 8- to 10-minute point the evolution of oxidized carbon practically ceased.

Correlation of Gas Evolution Data with Previous Data

It was found possible to distinguish between strongly-blistering and weakly-blistering irons on the basis of the breadth of the range of firing periods within which enameling could be accomplished with relative freedom from blisters. If an iron has a sufficiently strong-blistering tendency, this range will be so narrow that it is virtually nonexistent, as in the case of iron L_2, 1–55 (Table III). An iron having a somewhat weaker blistering tendency, as L_2, 3–55 in the same table, gave much better results at both 5 and $7^1/_2$ minutes of firing the ground coat than at the longer periods, while with iron R_2, 2–56, the range was so broad that the results were still moderately good at the 15- to $17^1/_2$-minute periods. In all cases, however, the average results at 3 minutes were unsatisfactory. The question arises as to just how these facts fit in with the foregoing data on gas evolution.

In the first place it is obvious that the amount of blistering will be controlled by the rate of gas evolution during that part of the firing process in which the cover coat is able to entrap the evolved gas, *i.e.*, after it has definitely begun to fuse. With this fact in mind it can be readily seen that when the firing period of the ground coat is very short, then according to the curves in Fig. 9, blisters should be expected to appear on even the best irons studied, since the cover coat will be fired while gas is still being evolved just as rapidly as from a strongly blistering iron.

In the case of the specimens which are fired longer, there are three factors to take into consideration. One is, of course, the steepness of the gas-evolution curve during the critical period; another is the degree of permeability of the ground coat, which increases as the firing period increases, and the third is the time-lag factor which influences the actual progress of the gas bubbles through the comparatively thick cover coat.

With any specific firing treatment the number and character of blisters will depend upon the rate of gas evolution (*i.e.*, steepness of the gas-evolution curve) during the critical part of the firing period. An iron in which this rate is intermediate will give comparatively good results within a narrow range at the shorter firing periods because the comparative impermeability of the ground coat and the time necessary for the evolved gas to work its way through the cover coat combine to delay the actual appearance of blisters at the surface of the specimen. If the ground coat is fired longer on an exactly similar specimen, it will not be impermeable enough to prevent the appearance of blisters during the firing

of the cover coat. This explanation would be applicable to iron L_2, 3–55 (Table III).

An iron in which the gas evolution is sufficiently copious during the critical period will give numerous blisters even at the most favorable firing period, although the effect of the lower permeability of the ground coat at this period is appreciable. Iron L_2, 1–55, typifies this case. (Table III.)

If gas evolution has practically ceased before the cover coat is fired, the added permeability of the ground coat at the longer firing periods has but little effect (though its overfired condition may be partially responsible for such blisters as appear), and the iron may be said to have a broad firing range. This case is typified by iron R_2,2–56 (Table III).

Study of Carbon in the Microchilled Surface

All of these tests described above serve to indicate, if not to prove, that the blister-forming gas is not SO_2, hydrogen from the decomposition of steam, or nitrogen from the decomposition of iron nitride. In all probability it is CO_2 and CO.

There is good evidence that the reactivity of different varieties of carbon and graphite varies greatly with the ratio of surface to volume of the particles, and with the mode of formation of the particles. Falcke,[11] for example, experimented with the rate at which amorphous carbon, purified in various ways, and purified natural graphite from different sources, reduced iron oxide in the presence of iron. The initial temperature at which reduction started and the rate at which it progressed varied markedly with the different varieties of carbon and graphite.

The CO and CO_2, moreover, formed by the oxidation of any form of carbon will affect the rate of decomposition of cementite both by decarburization, which alters the amount of carbon, and hence its distribution between the graphitic and combined forms and, according to Hayes,[12] by a catalytic action.

It has been noted in commercial enameling that adhesion of enamel, for which a certain degree of oxidation of the surface of the iron is thought to be desirable, varies according to the size of the load with respect to the size of the furnace. This indicates that there may not always be enough oxygen available in the furnace atmosphere effectively to oxidize a large surface of graphite particles.

The weight of evidence strongly indicates that carbon in some one or more of the possible forms, ordinary graphite, submicroscopic graphite,

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[11] V. Falcke, "The Reaction between Ferrous Oxide and Carbon, and between Carbon Dioxide and Iron," *Z. Electrochemie*, **21**, 37 (1915).

[12] A. Hayes and H. E. Flanders, "The Catalysis of the Graphitization of White Cast Iron by the Use of CO–CO_2 Mixtures When Applied under Pressure," *Trans. Amer. Foundrymen's Assn.*, **33**, 575 (1925).

"temper carbon," or combined carbon (cementite), plays a major rôle in the formation of blisters, and the problem appears to resolve itself into a study of carbon in the microchilled surface.

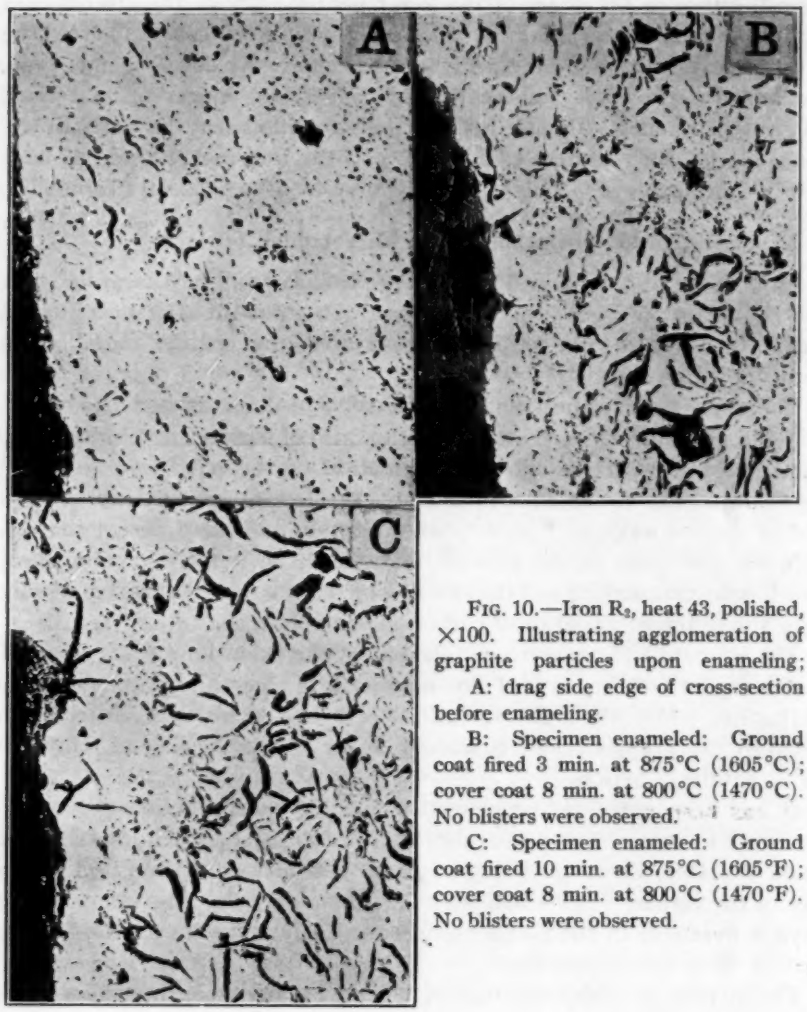

FIG. 10.—Iron R_2, heat 43, polished, ×100. Illustrating agglomeration of graphite particles upon enameling;

A: drag side edge of cross-section before enameling.

B: Specimen enameled: Ground coat fired 3 min. at 875°C (1605°C); cover coat 8 min. at 800°C (1470°C). No blisters were observed.

C: Specimen enameled: Ground coat fired 10 min. at 875°C (1605°F); cover coat 8 min. at 800°C (1470°F). No blisters were observed.

Ordinary Graphite

It is unlikely that massive graphite is responsible for blistering. It is true that finely-divided graphite smeared on the surface of the iron as by writing on the iron with a pencil gives blisters, and that carbonaceous

mold facings are probably to be avoided, though very light applications have been successfully used.

One might assume that in severe sandblasting, which is known to mini-

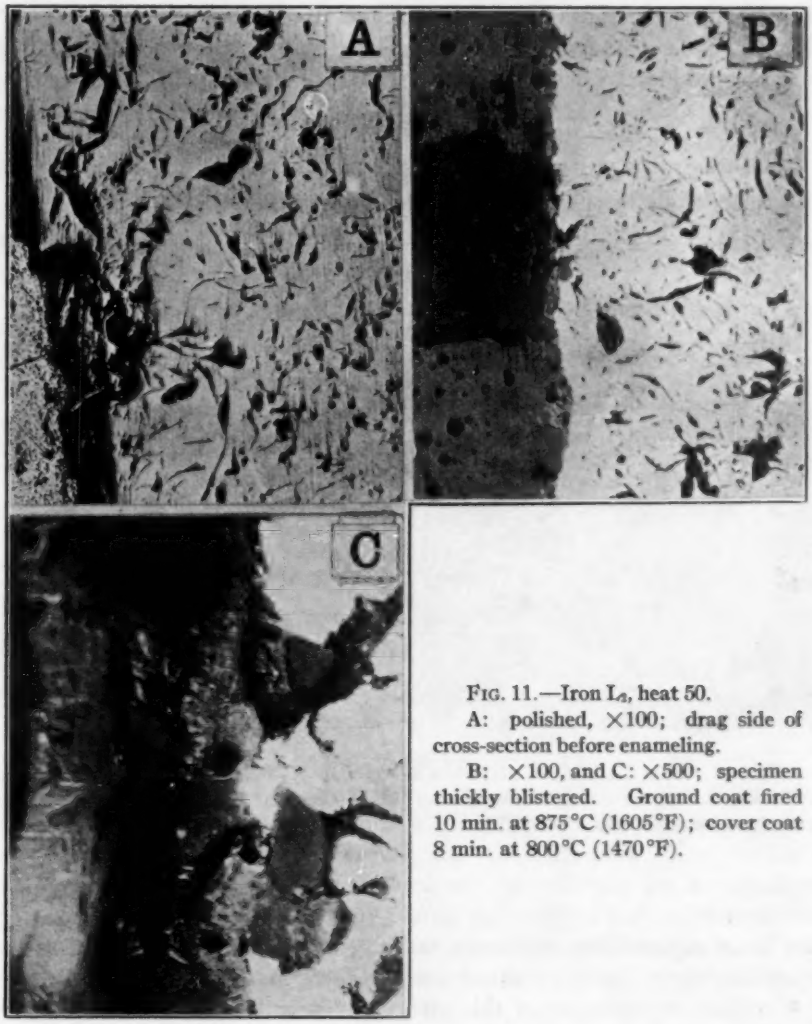

FIG. 11.—Iron L_3, heat 50.

A: polished, ×100; drag side of cross-section before enameling.

B: ×100, and C: ×500; specimen thickly blistered. Ground coat fired 10 min. at 875°C (1605°F); cover coat 8 min. at 800°C (1470°F).

mize blistering, the graphite flakes may be dug out and removed and leave a practically graphite-free surface. Microscopic examination, however, shows that graphite flakes may extend to the very surface of the metal without causing blisters (see Fig. 10C). On the other hand graphite flakes may appear at the surface of a specimen which does blister (Figs.

11 and 12). Such flakes may cause local poor adherence of the enamel. Poor adherence, however, does not seem to be necessarily connected with blistering, which fact is illustrated in Fig. 7.

A machined surface of the blistering iron L_2, moreover, does not blister, and it is certain that machining does not drag out and remove all the graphite flakes. Massive graphite in itself cannot be considered as invariably producing blisters.

Submicroscopic Graphite

The assumption was made that aside from the regular graphite particles visible under high and low magnification, there are particles beyond the

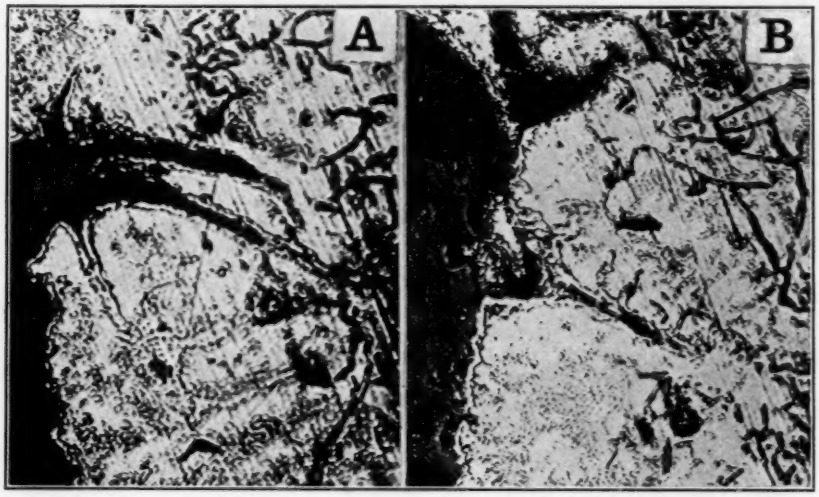

FIG. 12.—Iron L_2, heat 50, etched in 2% HNO_3, × 500. A and B: This specimen was thickly blistered. Ground coat fired 10 min. at 875°C (1605°F); cover coat fired 8 min. at 800°C (1470°F).

resolution of the microscope. On account of their small size, these particles should be very active and should readily respond to the heat, *i.e.*, they may agglomerate to somewhat larger groups or may burn away, depending upon the temperature used.

A certain confirmation of this idea is given in the following statement by Ropsy.[13]

In fact, in the hardened part of a chilled casting (cooled, therefore, very rapidly and solidified almost without transformation) there remains up to 0.15% of carbon in the form of graphite. To effect this determination with precision, at least 5 grams of metal must be dissolved, the de-

[13] P. Ropsy, "Carbon in Cast Iron," *Foundry Trade Jour.*, **36**, 199 (1927).

termination of graphite being carried out on the residue. The microscope, even with the highest magnification, does not show this graphite, probably because it is disseminated throughout the mass in the form of particles which are too minute.

If these particles are in fact disseminated "throughout the mass," it is obvious that they could cause the evolution of gas even after the removal of the surface layer of a casting and may be responsible for a large evolution of gas in the first period of firing.

In fact, it is believed probable that the comparatively rapid evolution of gas during the first 8 to 10 minutes of firing (Fig. 9) is in all cases caused by the oxidation of these submicroscopic particles of graphite, which are presumed to be present in approximately equal concentration (1) in the surface layer of the weakly-blistering iron, (2) beneath the surface of the weakly-blistering iron, and (3) in the surface layer of the strongly-blistering iron, but in greater concentration beneath the surface of the strongly-blistering iron. In all cases the oxidation of this type of carbon is probably completed in the 8- to 10-minute period, and is not responsible for any subsequent evolution of gas.

Combined and Temper Carbons

Chilled iron, with practically all of the carbon in the combined form has been said by some to blister and by others not to blister.[14] It was thought that the explanation of this difference of opinion might lie in the individual conditions surrounding each observation, which in some cases tend to promote and in others to retard graphitization. These conditions are believed to include the degree of massiveness of the cementite formation, the presence or absence of elements which tend to stabilize cementite, superheating of the melt, and other conditions. In order to throw some light on this question, the following experiments were carried out.

Samples of white iron (plow shares) were subjected to the standard enameling tests, and were found to blister badly over the whole range of firing temperatures. Specimens from which the surface had been deeply machined still blistered just as badly.

On annealing this white iron at 950°C (1740°F) for five hours and cooling in the furnace, the tendency to blister was much reduced. The specimens tested at the shorter firing periods of the "range" method were practically perfect.

The surface was decarburized by the long heating. Specimens, however, from which the decarburized surface had been removed by machining, so that the enamel was applied on a surface that was not decarburized,

[14] A. Malinovszky, "Enameling Defects Due to the Cast Iron," *Jour. Amer. Ceram. Soc.*, **8**, 72 (1925), states that low-combined carbon, *i.e.*, high-graphitic carbon, favors freedom from blisters, and high-combined carbon makes the iron more prone to blister.

were equally as good as those enameled on the decarburized surface. Such long annealing was not required since heating to 900°C (1650°F) for 45 minutes followed by furnace cooling was also effective in greatly diminishing blistering.

The annealing altered the structure decidedly by producing well-agglomerated "temper carbon," *i.e.*, practically massive graphite. In the short heating of the enameling process, there was evident decomposition of cementite but very little agglomeration. On the other hand, a specimen of malleable iron in which microscopic examination showed most of the "temper" carbon to be well agglomerated did not blister (rating 1) when the firing time of the ground coat was $7^1/_2$ or 10 minutes, but did blister badly (rating 4 to 5) at $12^1/_2$ and 15 minutes. Well-agglomerated temper carbon thus appears nearly as nonreactive as massive graphite. The distinction between agglomerated temper carbon of malleable iron and massive graphite of gray iron is therefore probably one of appearance rather than of chemical reactivity.

The great reactivity of colloidally dispersed temper carbon, just as it forms and before it agglomerates, is in sharp distinction to the lower activity of the agglomerated material.

In order to study a mild chilling effect on the weakly-blistering castings, the iron R_2 was cast in the usual $^3/_{16}$-inch thick plates in a variety of sand molds as follows: (*a*) skin dried, (*b*) moisture content, 6 to 7%, and (*c*) moisture content, 10%. This heat was designated No. 65.

The specimens were enameled in the regular way except that the time of firing of the ground coat was $12^1/_2$ minutes, since this longer time of firing seemed to accentuate the tendency to blister. All specimens were graded No. 2 with respect to blistering. These results indicated that the variations in moisture content of molding sand used were not pronounced enough to cause chilling sufficient to affect the blistering tendency.

Some interesting results were obtained when definite chilling of the surface was resorted to. Strongly-blistering iron L_2 and weakly-blistering iron R_2 were cast in blocks 3 x 6 x 2 inches, in various ways; *e.g.*, (*a*) in green sand, (*b*) against a chill plate covered by $^1/_4$ inch of green sand, and (*c*) directly against a chill plate. Slabs $^3/_{16}$-inch thick were then cut from the blocks, the slab from the drag side being designated A and the next

TABLE XVII

ENAMEL RATINGS OF IRON SPECIMENS WITH CHILLED SURFACES

Specimen	Iron	Character of iron	Enamel ratings		
			Green sand	Sand over chill plate	Chill plate
A	L_2	Strongly blistering	4–5	4–5	4–5
	R_2	Weakly "	1–2	4	2–3
B	L_2	Strongly "	2	2	2
	R_2	Weakly "	2	2	4–5

$^3/_{16}$-inch slice B. The surfaces enameled were the drag face on A, and on B the surface $^3/_{16}$ inch from the drag side. The standard enamel with $12^1/_2$-minute firing of the ground coat was used. The results are given in Table XVII.

Consider first the results in green sand. It will be noted that away from the surface, the body of the strongly-blistering iron gives good enamel ratings. This is the equivalent of an ordinary strongly-blistering test plate from which the microchilled surface has been machined. The weakly-blistering iron behaves the same at the surface and in the interior.

When the surface was slightly chilled by casting against $^1/_4$ inch of green sand over a chill plate, the iron termed as "weakly" blistering took on a casting surface that was as poor as that of the iron termed "strongly" blistering. Removal of the surface produced the same improvement in both. Under such casting conditions the irons are identical in behavior as to blistering. Irons R_2 and L_2 do not appear very different in nature. One is slightly over the dividing line in one direction, the other in the other.

When the surface is more strongly chilled by casting directly against a chill plate, the strongly-blistering iron acts just as it did with less severe chilling. The weakly-blistering iron, however, has less blistering tendency on the strongly-chilled surface (cast against a chill plate) than it has either on the weakly-chilled surface (cast against sand over a chill plate) or on the B slice of the strongly-chilled one.

The decomposition of cementite from combined carbon to temper carbon or graphite, taking place in a chilled or microchilled layer during enameling, will doubtless depend on (*a*) the original content of combined carbon, (*b*) the composition of the iron as to elements that promote or hinder graphitization, and (*c*) the time and temperature of enameling.

If all these conditions are such that there is no breakdown of combined carbon during enameling, but what combined carbon is present remains as such, it may be assumed that the iron does not blister. Under this assumption, either stable white iron, or stable gray iron would be "non-blistering," but if the chilled layer contains combined carbon that does break down to colloidally dispersed temper carbon during a certain period of the enameling process, it will blister. If the enameling process is carried out at a high temperature and for a long time (*e.g.*, 15- or $17^1/_2$-minute firing periods) the blistering tendency will be accentuated either because the combined carbon, although stabilized, may begin to break down under this treatment or because the graphite may begin to oxidize under such conditions. If the same iron is enameled with a shorter firing period, or at a lower temperature or with more fusible enamels, the iron may not blister.

Thus, the blistering for which combined carbon is responsible may be traced to the breakdown of combined carbon to temper carbon at a stage

TABLE XVIII

CHANGE IN HARDNESS OF IRON DURING ENAMELING

Iron	Melts	Heat No.	Carbon			Mn (%)	P (%)	S (%)	Si (%)	Hardness before Enameling		Hardness after Enameling		Decrease in Hardness (%)	
			Total (%)	Graphitic (%)	Combined (%)					Shore scleroscope	Rockwell B scale	Shore scleroscope	Rockwell B scale	Shore scleroscope	Rockwell B scale
L_1	Cupola	6	3.65	2.97	0.68	0.56	0.46	0.05	2.16	47.4	96.2	33.9	79.8	28.5	17.0
L_1	"	14	3.47	3.07	.40	.57	.46	.076	2.24	48.4	93.2	35.7	76.8	26.2	17.6
L_1	Cupola melted 3 times	16	3.47	2.95	.52	.33	.47	.095	1.92	50.4	96.8	35.1	81.3	30.4	16.0
L_1	Cupola with 0.1% S in the ladle	22	3.59	2.99	.60	.56	.45	.121	2.22	47.3	95.6	36.4	81.1	23.0	15.1
L_1	Electric furnace	17	3.76	3.10	.66	.63	.47	.038	2.19	43.4	89.4	33.0	81.3	24.0	9.1
L_1	Electric with 0.1% S in the ladle	20	3.81	3.09	.72	.65	.45	.10	2.13	46.8	93.8	32.9	80.5	29.7	14.1
L_1	Electric with 0.13% S charged with iron	28	3.67	3.09	.58	.61	.43	.092	2.21	46	94.6	33.1	82.5	28.0	11.1
R_1	Cupola	7	3.40	3.18	.22	.69	.81	.048	2.82	46	94.6	40.9	89.7	11.1	5.2
R_1	Electric with 0.16% S added to molten iron in the furnace	26	3.58	3.09	.49	.77	.79	.09	2.93	42.6	92.2	35.8	77.3	15.9	16.2
L_2	Electric	44	3.60	3.15	.45	.71	.49	.043	2.44	46.5	93.3	38.5	75.7	17.2	19.0

during enameling at which oxidation can occur and at which the enamel is in such a physical condition as to retain the CO and CO_2 formed.

If the breakdown at this stage is prevented, there will be no "nascent" temper carbon to cause blisters. It may be prevented by the nature of the chilled layer itself, by removing the offending surface layer, by avoiding conditions that will produce this layer, by decarburizing the surface, or by accomplishing the breakdown before the enameling operation.

To recapitulate: Stable cementite is not necessarily readily oxidized to give the CO_2 or CO gases that appear to be responsible for blistering. Neither does massive graphite whether formed as such during solidification and cooling of gray iron, or as a product of decomposition of cementite on annealing, appear responsible for blistering. It does appear, however, that an intermediate structure, resulting from the partial breakdown of cementite on annealing and partial agglomeration to graphite, is the most active in producing blisters.

The enameling process itself is a short anneal. The decomposition of cementite will be accelerated by the presence of graphite in the original casting. Agglomeration of small, widely distributed particles of primary graphite into large flakes is clearly shown by Figs. 10A, B, and C, in whch the progressively increased agglomera-

tion of graphite particles with increased firing periods is very plain. Even the body of a gray-iron casting is changed in structure and hardness by the heat-treatment incidental to enameling.

Change of Hardness and Structure on Enameling

Table XVIII shows the decrease in hardness that takes place on enameling. Metallographic examination of a number of specimens showed that a considerable change in the structure of the iron occurred during the enameling process and this change often was not confined to the surface layer but took place throughout the section of the specimens. A specimen which before enameling contained a lamellar pearlite matrix throughout its section (Figs. 13A and B) showed after enameling the large ferritic areas and dendritic structure similar to those represented in Figs. 13C and D. The remainder of the pearlite usually was partly spheroidized and partly changed to sorbite.

It was noted that some specimens of weakly-blistering iron appeared to undergo no change detectable under the microscope during enameling. Figure 14B at × 100 shows a weakly-blistering specimen, the surface of which when examined at × 500 after enameling appeared to be unchanged from the pearlitic structure of the unenameled specimen shown in Figure 14A. It was thought for a time that a lower blistering tendency might be associated with a smaller change in structure, but it was found later that this was not always true and that a marked change in structure often occurred in weakly-blistering as well as in strongly-blistering specimens.

Much attention was paid to the habit of graphite, *i.e.*, whether it was in fine flakes, only slightly agglomerated, or almost entirely agglomerated in the "whirl" form, but the observations seemed to justify the conclusion that the habit of the graphite is not definitely associated with the blistering tendency.

Burning Out

The familiar "burning out" or normalizing in air so often resorted to by the enameler to prevent blistering may be considered as accomplishing various things: (1) it removes some of the surface layer of metal by oxidation; (2) it tends to decarburize and hence soften the layer of metal beneath the oxide coat; (3) it softens the metal as a whole. Hence, when a "burned out" casting is sandblasted, the loose oxide comes off readily, and the surface, now softer than before enameling, is more readily removed by sandblasting.

Effect of Elements in Cast Iron on Chilling Tendency

The formation of the microchill appears to be a matter of delicate balance as is evidenced by Table III, where some heats of the "strongly-blistering" northern iron are shown to be better than some heats of the "weakly-blistering" iron.

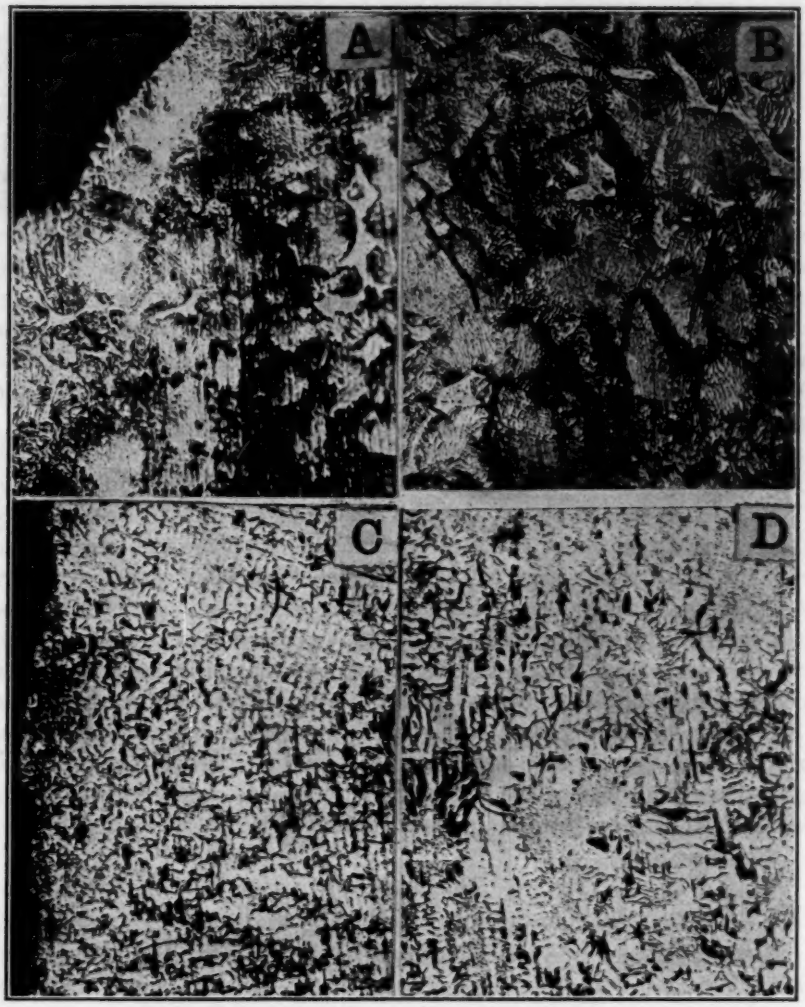

FIG. 13.—Iron L_1, heat 16; etched in 5% picric acid.
A and B specimen before enameling.
A: Cross-section at drag side, ×500.
B: Cross-section near center of casting, ×500.

C and D: After enameling, ×100. C: Part of cross-section adjacent to enamel; D: central part of cross-section. A number of blisters were observed on this specimen. Ground coat fired 8 min. at 870°C (1600°F) and cover coat 7 min. at 840°C (1545°F).

The question then arises: can the composition of the "blistering" irons be so adjusted that the microchill will not form, or will not be too deep and too hard for complete removal by ordinary sandblasting. In order to bring this about, it would be quite natural to add some element that would tend to foster graphitization and prevent the retention of combined carbon. The addition in proper manner and proportion of silicon, aluminum, or nickel, well-known graphitizing agents as previously discussed, indicated that some improvement may be accomplished by such means,

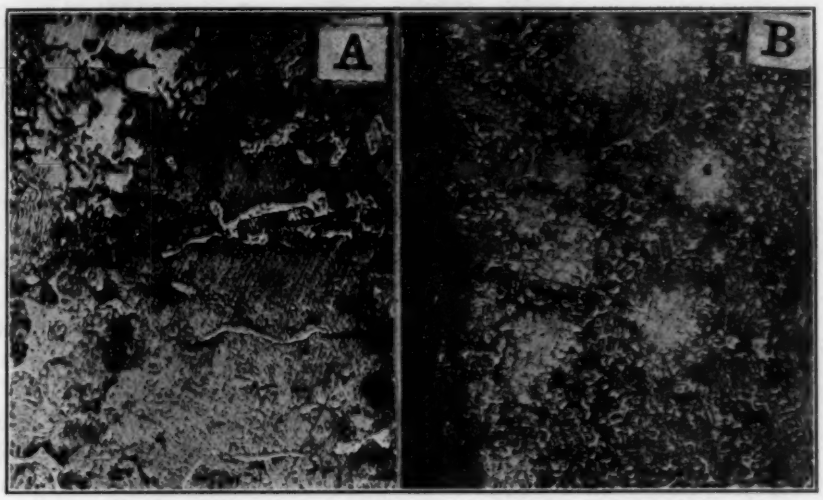

FIG. 14.—Etched in 5% picric acid. (Composition, C 3.46%; graphitic C 2.85%; combined C 0.61%; Mn 0.52%; P 0.510%; S 0.101%; Si 2.22%.)

A: Specimen before enameling, ×500; edge of cross-section at drag side.

B: Specimen enameled, ×100; no blisters were noticed on this specimen; ground coat fired 5½ min. at 900°C (1650°F); cover coat fired 6 min. at 840°C (1545°F).

particularly in the case of silicon, if added. The "microchill" appears to be more difficult to prevent than the ordinary chill which can be readily controlled by properly adjusting the composition and the rate of cooling. It seems reasonable, however, that all changes that tend to prevent the formation of the ordinary chill would also be steps in the right direction in the prevention of the "microchill." We may, therefore, turn to a brief consideration of the effect of the various alloying elements on the chilling of cast iron, *i.e.*, the formation of combined carbon.

Gray cast iron, such as is used for enameling, contains carbon, silicon, sulphur, manganese, and phosphorus, besides small amounts of other elements. The properties of the iron are very greatly affected by the con-

dition of the carbon, and this is controlled as much by the rate of cooling as by the composition. When the metal freezes the carbon is in combination with iron as the compound Fe_3C (cementite). Manganese, chromium, or other carbide-forming elements form similar carbides, and cementite will normally be contaminated with more or less of those carbides. If the metal is chilled very rapidly the cementite is retained without decomposition, and white or chilled iron which is practically free from graphite will result. Cementite is brittle and hard and since white cast iron contains so much cementite it also has these qualities.

If the metal is allowed to cool more slowly during and after solidification some of the cementite will decompose and form iron (ferrite) and free carbon (graphite or temper carbon). The resulting product "gray iron," is much softer than white iron.

The total amount of carbon in ordinary cast irons does not vary very much, but the relative amounts of free carbon and of combined carbon (cementite) do vary greatly, not only with the rate of cooling, but also with the other elements present.

Silicon At a given rate of cooling, a higher silicon content is favorable toward a higher-graphite and a lower-combined carbon content. The silicon content is the chief factor controlling the ratio of graphite and combined carbon, and the chief agent in securing soft gray iron instead of hard white iron.

Phosphorus Phosphorus is alleged to foster graphitization and thus tends to make soft iron. But iron phosphide itself is hard and brittle so that a high phosphorus iron tends to be hard notwithstanding the increased precipitation of graphite. The iron phosphide has a low melting point and the fusibility of the iron is much increased by increase in phosphorus. Since the melting point is lower the pouring temperature can be lower, and hence the rate of cooling will be altered. The action of phosphorus is, therefore, complex.

Sulphur and Manganese Sulphur tends to oppose the precipitation of graphite, especially when present as iron sulphide. If sufficient manganese is present, the sulphur will be combined as manganese sulphide which is more inert in its effect on precipitation of graphite. The ratio of manganese to sulphur, therefore, governs the effect of the sulphur up to the point (often taken as 7:1) where manganese is in decided excess of the amount necessary to force practically all the sulphur into manganese sulphide. Up to this point, then, manganese is in a way a softener because of its effect on sulphur.

Shaw[15] denies that manganese aids the retention of carbon as cementite

[15] J. Shaw, "Theory and Practice in the Gray Iron Foundry," *Trans. Amer. Foundrymen's Assn.*, **36**, 293 (1928); "Influence of Elements on Cast Iron Structure," *Foundry*, **54**, 767, 771, 825 (1926).

and ascribes the increased Brinell hardness to the effect of manganese in altering the microstructure, the matrix tending to be sorbitic and the graphite in "whirl" form. Parker,[16] however, insists that manganese does increase the stability of the carbide. The effect of increased sulphur in slowing down the rate of graphitization of white cast iron, and the counteracting effect due to manganese additions is brought out by some investigators.

Cupola remelting would be expected (see Table I) to lower the silicon and manganese somewhat and to raise the sulphur, with consequent decrease of the ratio of manganese to sulphur. This change is accompanied by an increase of combined carbon which causes a hardening of the iron. Cupola remelting would thus be expected to act in a detrimental manner rather than a beneficial one on blistering. No satisfactory evidence has been obtained in support of the idea that remelting was beneficial.

Manganese in excess of the amount required to combine with sulphur, however, is usually considered a hardener, which forms a stable, manganese-bearing cementite and increases the depth of chill. Guedras[17] says that in black-heart malleable castings the formation of a finely-dispersed type of temper carbon rather than of large graphite particles is favored by the stabilizing action of manganese upon cementite.

The graphite precipitated from cementite as the casting cools presumably appears first as very finely divided, even submicroscopic, "temper carbon," which is chemically and structurally the same as massive graphite but very much more finely divided, hence much more reactive.

Summary

The data obtained in this investigation appear to support the explanation of blistering which is summarized in the following paragraphs and which is the only one known to the authors that fits the facts so far observed.

(1) There is ample evidence that physical defects, especially "sponginess," will give rise to blisters. An enamel, moreover, may be composed, prepared, or applied in such a manner as to cause blisters irrespective of the character of the iron used. There are differences, however, in the tendencies of sound castings made from different lots of iron or made from the same iron under different conditions to give blisters when enameled under identical conditions. The gases forming the blisters are CO and CO_2.

(2) A gray-iron casting of the composition normally used for enameling acquires in freezing and cooling a very thin surface skin, which may be considered as a "microchill." This layer extends only a few thou-

[16] W. B. Parker, Discussion, *Trans. Amer. Foundrymen's Assn.*, **36**, 849 (1928).

[17] M. Guedras, "Theoretical Consideration of the Precipitation of Carbon in Black Malleable Castings," *Fonderie Moderne*, **20**, 66, 247 (1926).

sandths of an inch below the surface and varies in thickness, hardness, and resistance to abrasion by the sandblast. Removal of this surface layer eliminates blistering except such as is caused by sponginess or other physical defects which extend more deeply into the interior. The analyses of the surface layers indicate that the hardness and resistance to abrasion may be due either to the higher combined carbon or to some other hard component.

(3) The cementite (combined carbon) of this skin tends to break down, during the enameling process, to very finely-divided "temper carbon." This form of finely-divided carbon is more readily oxidized, as would be expected from its fineness, than massive graphite or combined carbon.

(4) This breakdown to a readily oxidizable form of carbon, analogous to the early stages of the malleableizing of white iron, leads to the formation and evolution of CO and CO_2 upon heating, which causes greater or less damage, according to the stage of the enameling process at which it occurs. If the enamel coat is sufficiently fused to form the gas into bubbles but not fluid enough to heal after any bubbles of gas have escaped, blisters will occur. If the craters partially heal there will be dimples. If the enamel is a low melting one, applied at a low temperature, the annealing action coincident with enameling may not be sufficient to produce a breakdown of the cementite accompanied by the formation of the finely-dispersed temper carbon, or, if it is produced and CO and CO_2 are formed, the enamel may be fluid enough to allow the gas to escape without damage.

(5) There are probably two kinds of nonblistering iron, one in which a small amount of combined carbon is present in the surface layer, and the other in which the cementite is so stable that it takes a relatively long time to break it down into ferrite and temper carbon.

(6) Decarburization of the skin, as well as its removal by mechanical or chemical means, will eliminate the source of temper carbon. Hence blister-free ware can be obtained with a sound casting if the enameling process itself is properly carried out, unless the whole casting is of such a nature that the body as well as the skin will give temper carbon on enameling. Some irons have a greater tendency to give the microchilled layer than others. The gas evolution which apparently takes place during the first part of the firing treatment, even from those specimens having the least blistering tendency of any studied, has been assumed to be due mainly to submicroscopic graphite, which burns out too quickly to cause blisters.

(7) Aside from such variations as may be attributed to differences in enameling procedure at the different plants, the presence of a hard surface layer or "microchill" probably accounts for most of the inconsistencies observed in the early part of the investigation, as well as those between

the results of various laboratories. Unless sandblasting was uniformly controlled and the surface layer uniformly attacked, it is obvious that erratic results would be obtained on enameling.

(8) Attempts to nullify the hardening effect of sulphur by addition of manganese do not appear to offer much hope, since excess manganese is in itself harmful.

Addition of some graphitizing agents such as silicon, or any precaution in casting that will tend to minimize the tendency to chill, may be beneficial but it is more difficult to prevent the formation of the microchill than the formation of the well-understood ordinary or macrochill.

(9) In cases when an occasional heat or lot of sound castings show a tendency to blister, "burning out" or deep sandblasting appears to be the most practical remedy.

Acknowledgments The work reported above by no means represents the efforts of any one person. It would have been impossible for the investigation to be carried out without the coöperation of various individuals whose contributions were of great importance. The part played by the Research Committee of the Enamel Division, AMERICAN CERAMIC SOCIETY, under the guidance of its chairmen, R. R. Danielson and H. F. Staley, has been described in the Progress Report published in this *Journal*, where credit was also given for the participation of H. G. Wolfram during his incumbency at the Bureau, and that of the late G. T. Thaler, who made a number of valuable suggestions. Excellent work was done by L. D. Jones in the preparation of castings.

The analytical work on gases and gas-forming elements was carried out by R. J. Kranauer and J. S. Acken of the Metallurgy Division. All other chemical analyses were made by H. A. Bright and assistants under the supervision of G. E. F. Lundell, of the Chemistry Division. The spectroscopic analyses were made by W. F. Meggers, of the Optics Division.

Grateful acknowledgment is made to L. Jordan for aid and counsel and especially to H. W. Gillett and C. M. Saeger, Jr., of this Bureau for their help and guidance throughout the investigation.

THE DEVELOPMENT OF AN ENAMEL ON A EUTECTIC BASIS[1]

By Harold Ellis Simpson

ABSTRACT

The object of the investigation was to develop a eutectic solvent for an enamel by the combination of several eutectics, then to add silica to increase the refractoriness of the enamel up to the limit of its capability to dissolve silica without endangering its bond to the metal body. This naturally involved a study of the eutectic compositions of the $RO–B_2O_3–SiO_2$ systems. Since the $Na_2O–B_2O_3–SiO_2$, $K_2O–B_2O_3–SiO_2$, and $PbO–B_2O_3–SiO_2$ deformation eutectics are known a knowledge of the $CaO–B_2O_3–SiO_2$ system was necessary. A study of the high B_2O_3 area of this system was made at approximately 4% intervals. A member high in CaO and SiO_2, and which on repeated fusions showed practically 100% glass, was selected as a practical member to blend with the $Na_2O–B_2O_3–SiO_2$ and the $PbO–B_2O_3–SiO_2$ eutectic to form a eutectic solvent for an enamel.

Combinations of these eutectics and the $CaO–B_2O_3–SiO_2$ mixture were made and applied to cast iron by the dry process. Additions of SiO_2 were also made to these enamels up to 1.5 molecular equivalents. The physical properties of these enamels such as brilliancy, smoothness of surface, texture, bonding power, solubility in water, and resistance to acid attack were also determined.

Introduction

A fundamental consideration in the development of an enamel is the eutectic solvent. If $RO–R_2O_3–SiO_2$ eutectics can be so combined as to dissolve the maximum amount of silica we would have an enamel with the greatest resistance to service abuse.

The term "eutectic" or "deformation eutectic"[2] is used here to designate that mixture which requires the least heat treatment to cause fluidity sufficient to result in the deformation of the mixture.

The object of this investigation was to develop a eutectic solvent and then by the addition of silica or some other refractory to harden the enamel or to increase its refractoriness up to the limit of its capability to dissolve silica without endangering its bond to the metal body.

A review of the literature shows that an enormous amount of work has been done on the thermochemical behavior of the chief constituents of an enamel.[3]

Preliminary Study

The first stage of the study was the $CaO–B_2O_3–SiO_2$ system in the high B_2O_3 corner of the triaxial. To get around bloating due to the liberation of the chemically combined water of the boric acid, fusions were made of the various members and these fusions were used as end members. Trouble was encountered in making the fusions. The members high in lime of both

[1] Presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the Graduate School, Ohio State University. Received June 10, 1929.

[2] See Bibliography, ref. 1 (at end of paper).

[3] See Bibliography, ref. 2 to 38.

the lime-borosilicates and lime-borates would eat through the walls and completely destroy the crucible.

Many types of crucibles were used, including fire clay, high bauxite, chemical porcelain, dense porcelain (cone 23), alundum (Norton Company), magnesia (Norton Company), sillimanite (Champion Spark Plug Company), fused silica, and graphite crucibles.

Fused silica was satisfactory for lime-borosilicates but not for lime-borates. A fusion was made in graphite crucibles of both lime-borosilicates and lime-borates, but there was a question as to whether the melt did not attack clay bond in the crucible.

To get away from this contamination of melts by the crucible, bars 1 by 1 by $4^3/_8$ inches were made of the end members. They were dry pressed, using water as a bond and a pressure of about one and one-half tons. These bars were placed on platinum-covered clay triangular supports, heated in a Hoskins resistance furnace until they sagged under their own weight, then turned over and heated until they sagged back again. These bars ground to pass a 100-mesh screen and made into cones, bloated as their fusion temperature was approached, especially those high in B_2O_3. The cones behaved little better than those made from the raw materials. This method was abandoned.

Melts were made of three lime-borosilicate members in fused silica crucibles. These melts were analyzed to determine any change in composition.

The following results were obtained from the analysis:

Member 1	Trials				
Ingredient	(1)	(2)		Mean	From diagram
SiO_2	33.66%	33.60%	=	33.63%	34.2%
CaO	4.34	4.42	=	4.38	3.6
B_2O_3 (by difference)	62.00	61.98	=	61.99	62.2
	100.00	100.00		100.00	100.0

Member 21	Trials				
Ingredient	(1)	(2)		Mean	From diagram
SiO_2	13.68%	13.10%	=	13.39%	14.8%
CaO	3.94	3.86	=	3.90	3.5
B_2O_3 (by difference)	82.38	83.04	=	82.71	81.7
	100.00	100.00		100.00	100.0

Member 16	Trials				
Ingredient	(1)	(2)		Mean	From diagram
SiO_2	17.80%	17.48%	=	17.64%	15.4%
CaO	22.88	22.68	=	22.78	21.5
B_2O_3 (by difference)	59.32	59.84	=	59.58	63.1
	100.00	100.00		100.00	100.0

Member 16 was fused twice owing to a white opaque scum that formed on top of a clear glass. The fusion was ground to pass a 100-mesh sieve and fused a second time in a silica crucible. A small amount of scum appeared.

This double fusion may account for the greater variation between "mean" and "diagram" results in this member than was noted in the others.

It is believed that these analyses were well within the accuracy of the other measurements possible in this experiment, including weighing up of the various members, temperature measurements, etc.

The white milky scum on top of Member 16 was examined, just after cooling from fusion, under the microscope by Professor McCaughey. The scum appeared to be well vitrified and apparently had very little that was not in solution. It had an index of < 1.46. On examination about one-half hour later it showed distinct evidence of devitrification and crystallization. This delayed crystallization is a characteristic of borosilicate glasses. We, therefore, had the added problem of getting all the material into solution. The glass below (clear) had an index of about 1.57.

Considerable difficulty was encountered in finding a binder for these glasses in making up cones. No aqueous solution could be used because glasses or fusions took up water quite readily and on fusion liberated this chemically-combined water, bloating the cones so that a true deformation could not be obtained. Many different binders were used, such as collodion, xylene, benzol, saturated alcoholic solution of balsam, and amyl acetate or banana oil.

Collodion was unsatisfactory as it would not mix with material and the ether would evaporate before cones could be made.

Xylene and benzol alone were unsatisfactory as they would not give cones proper strength in dry state for handling.

A saturated alcoholic solution of balsam and banana oil gave the best results, giving a cone that could be handled in dry state, would not bloat on fusion or leave any evidence of black coring or unfired organic matter in a deformed cone.

Method of Study and Raw Materials

The method of procedure was to make up 200-g. batch end members. These members were made into bars about one inch square and four inches long, and were dry pressed. Water was used as a lubricant. After bars were dried they were cut into cubes, 1 by 1 by 1 inch. The object in forming cubes was to have a material in such condition that it could be added to the crucible while the crucible was still in the furnace, and thus make successive fusions. The crucibles were too small for a 200-g. batch, hence the fusion of the batch was accomplished by fusing a few cubes at a time, bringing them to quiet fusion and pouring into a cast-iron ingot mold. The operation was repeated until the entire batch was fused. The materials thus accumulated were finally ground together into a single batch.

The raw materials used were Baker's C.P. crystalline boric acid and calcium carbonate. The flint used had the following analysis:

SiO_2	99.42%	TiO_2	0.006
Ignition loss	0.09	CaO	.02
H_2O	.03	MgO	.01
Al_2O_3	.06	KNaO	.14
Fe_2O_3	.04		
			99.816%

These end members were then ground to pass a 150-mesh screen, placed in ground glass stoppered bottles, and the bottles kept in a desiccator. The melts were first broken up in a steel mortar, then a magnet worked through the material to remove iron. The completed grinding was done with an agate mortar. Each member was weighed up in 5-g. batches. Three cones were made of each member. All cones were made about two-thirds standard size and banana oil (amyl acetate) was used as a binder. In

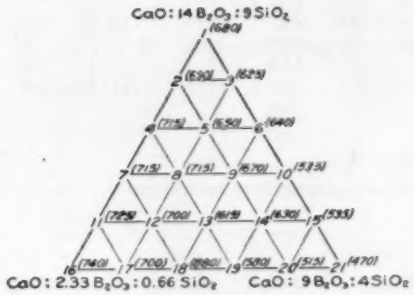

FIG. 1.

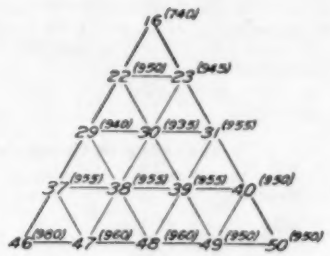

FIG. 2.

planting the cones in the plaque, finely-powdered alumina was used between cone and plaque to prevent reaction between the two.

The deformation behavior of the cones was watched from a peephole in the front door of an electrically-heated muffle furnace. Temperatures and time were recorded. The deformation was judged by the starting and finishing temperature and time. With time accurately taken, the interval between "started" and "down" is a measure of the comparative viscosities. For some of the cones high in B_2O_3, deformations were obtained before a temperature was raised sufficiently high to see into the furnace without the use of an electric light.

Results[4]

Study A The first area studied was the area bound by members 1, 16, and 21. These end members have the following composition:

Member			
1	CaO	$14B_2O_3$	$9SiO_2$
16	CaO	$2.33B_2O_3$	$0.66SiO_2$
21	CaO	$19B_2O_3$	$4SiO_2$

[4] See Bibliography, reference 39.

These members were fused in a fused silica crucible and heated in a gas-fired surface combustion furnace. Member 16, on account of scum on top of the melt was fused twice.

TABLE I

End Members 1, 16, 21; 4% intervals

Member	Temp. (°C)	Time "Started"	Time "Down"	Interval (min.)	Member	Temp. (°C)	Time "Started"	Time "Down"	Interval (min.)
1	680	4:02	4:04	2	11	725	4:08	4:15	7
2	690	11:52	11:57	5	12	700	11:57	12:01	4
3	625	3:40	3:46	6	13	615	11:30	11:33	3
4	715	3:59	4:10	11	14	630	3:40	3:50	10
5	650	3:54	3:57	3	15	535	11:13	11:15	2
6	640	3:42	3:52	10	16	740	4:19	4:21	2
7	715	4:02	4:11	9	17	700			
8	715	4:03	4:10	7	18*	880	12:00	12:54	54
9	670	3:57	4:00	3	19	580	11:20	11:24	4
10	535	1:12	1:15	3	20	515	11:07	11:11	4
					21	470	11:25	11:31	6

* Cone froze.

TABLE II

ARRANGED IN ORDER OF TEMPERATURE DEFORMATIONS

Member	Temp. (°C)	Interval (min.)	Member	Temp. (°C)	Interval (min.)
21	470	6	1	680	2
20	515	4	2	690	5
10	535	3	12	700	4
15	535	2	17	700	
19	580	4	8	715	7
13	615	3	7	715	9
3	625	6	4	715	11
14	630	10	11	725	7
6	640	10	16	740	2
5	650	3	18	880	54
9	670	3			

This series showed no relation between temperature of deformation and viscosities.

Study B The second area studied was bound by members 16, 46, and 50. These members have the following compositions:

Member			
16	CaO	$2.33B_2O_3$	$0.66SiO_2$
46	CaO	$1.4B_2O_3$	
50	CaO	$3.0B_2O_3$	

Members 46 and 50 were fused in a large platinum dish placed on a platinum tripod in an electric muffle furnace (Hoskins furnace). Member 50 having a scum on top of clear glass was fused twice. Member 46 came out a white opaque glass with the first fusion and was only fused once. Both fusions were held at about 1000°C for approximately three hours.

TABLE III

End Members 16, 46, 50; 4% intervals

Member	Temp. (°C)	Time "Started"	Time "Down"	Interval (min.)
22	950	4:48	4:49	1
23	945	4:44	4:48	4
29	940	4:43	4:47	4
30	935	4:43	4:46	3
31	955	4:49	4:50	1
37	955	4:49	4:50	1
38	955	Very fast from 20–30 sec.		
39	955	" " " " "		
40	950	" " " " "		
46	980	4:59	5:01	2
47	960	Very fast from 20–30 sec.		
48	960	" " " " "		
49	950	" " " " "		
50	950	" " " " "		

TABLE IV

ARRANGED IN ORDER OF TEMPERATURE DEFORMATIONS

Member	Temp. (°C)	Interval (min.)	Member	Temp. (°C)	Interval (min.)
30	935	3	31	955	1
29	940	4	37	955	1
23	945	4	38	955	Very fast
22	950	1	39	955	" "
40	950	Very fast	47	960	" "
49	950	" "	48	960	" "
50	950	" "	46	980	2

This series showed no relation between deformation and viscosity.

Study C The third area studied was bound by members 21, 51, and 55. These members have the following composition:

Member			
21	CaO	$19B_2O_3$	$4SiO_2$
51	CaO	$3.8B_2O_3$	
55	CaO	$23B_2O_3$	

Glasses were made of each of the above end members (21 having been fused before in a fused silica crucible). Glasses 51 and 55 when poured

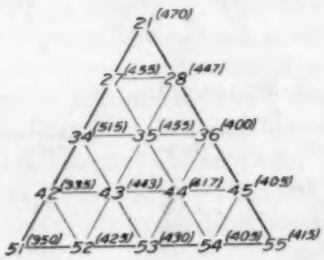

FIG. 3.

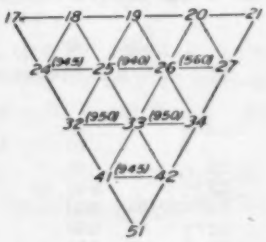

FIG. 4.

were white opaque glasses but on cooling an opaque scum crystallized on top; 51 and 55, however, were only fused once.

TABLE V

End Members 21, 51, 55; 4% Intervals

Member	Temp. (°C)	Time "Started"	Time "Down"	Interval (min.)	Member	Temp. (°C)	Time "Started"	Time "Down"	Interval (min.)
21	470	11:25	11:31	6	44	417	11:16	11:19	3
27	455	11:22	11:27	5	45	405	11:14	11:16	2
28	447	11:20	11:25	5	51	950			
34	515	11:40	11:43	3	52	425	11:18	11:20	2
35	455	11:23	11:27	4	53	430	11:18	11:22	4
36	400	11:13	11:15	2	54	405	11:13	11:16	3
42*	935	12:40	4:00	180	55	415	11:15	11:18	3
43	443	11:19	11:24	5					

* Cone froze.

TABLE VI

ARRANGED IN ORDER OF TEMPERATURE DEFORMATIONS

Member	Temp. (°C)	Interval (min.)	Member	Temp. (°C)	Interval (min.)
36	400	2	43	443	5
45	405	2	28	447	5
54	405	3	35	455	4
55	415	3	27	455	5
44	417	3	21	470	6
52	425	2	34	515	3
53	430	4	51	950	

This series showed no relation between cone deformation and viscosity.

Study D The fourth area studied was bound by members 17, 21, and 51. These members have the following compositions:

Member			
17	CaO	$3.0B_2O_3$	$0.8SiO_2$
21	CaO	$19B_2O_3$	$4SiO_2$
51	CaO	$3.8B_2O_3$	

Members 21 and 51 having been used in previous studies were already prepared. Member 17 was held in fused state in a platinum dish at 1000°C for about two hours. Owing to scum forming on top of a clear glass this member was fused a second time.

TABLE VII

END MEMBERS 17, 21, 51; 4% INTERVALS

Member	Temp. (°C)	Time "Started"	Time "Down"	Interval (min.)
24	945	Very fast about 30 sec.		
25*	940	11:55	1:09	74
26	560	11:16	11:19	3
32*	950	12:01	1:09	68
33	950	Very fast about 30 sec.		
41	945	1:01	1:09	8

* Cones froze.

This series showed no relation between cone deformation and viscosity.

Figure 5 is an isothermal diagram showing the results of the cone deformation study in studies A, B, C, and D given above in detail. The diagram as a whole shows a general sloping or trend in deformation tem-

TABLE VIII

ARRANGED IN ORDER OF TEMPERATURE DEFORMATIONS

Member	Temp. (°C)	Interval (min.)
26	560	3
25	940	74
41	945	8
24	945	½
33	950	½
32	950	68

peratures toward the high B_2O_3 area. This sloping or trend is very abrupt or precipitous from member 16 down through 51 and 52. The members deforming at 950°C or higher had very low viscosity or deformed quite rapidly, suggesting the possible formation of a compound or compounds with definite melting points. In this study conducted at approximately 4% intervals there is no evidence of an isolated member having the lowest deformation temperature.

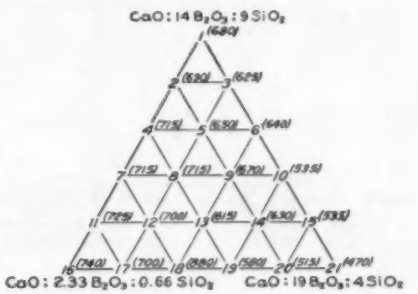

FIG. 5.

Eutectics as an Enamel Base

Since there was no evidence of a deformation eutectic from the cone fusion study (Fig. 5) it was necessary to select from that study a member high in lime and silica which is isotropic (well vitrified with everything in solution). This member was to be blended with other eutectics in order to develop a solvent for an enamel.

The following members were heat-treated to quiet fusion and then air-quenched by pouring into a cast-iron ingot mold where they were allowed to cool. They were then examined microscopically to see if any crystalline material was present and how much glass was present.

(A) (CaO–$6.0B_2O_3$–$5.0SiO_2$) was fused in a fused silica crucible. This fused member showed a large amount of crystalline material with some glass matrix.

(B) (CaO–$5.0B_2O_3$–$6.0SiO_2$) was fused in a sillimanite crucible. This fused member also showed a considerable amount of crystalline material with some glass matrix.

(C) (CaO–$2.5B_2O_3$–$2.5SiO_2$) was fused in a fused silica crucible. This

fused member showed a considerable amount of crystalline material with some glass matrix.

(D) (CaO–$1.33B_2O_3$–$1.66SiO_2$) was fused in a fused silica crucible. This fused member showed a rather large amount of crystalline material (more than C) with glass matrix.

Members 1 and 21 had been fused only once before while member 16 had been fused twice. These members were all fused again in a platinum dish.

Member 1 (CaO–$14B_2O_3$–$9SiO_2$): This fused member formed an opaque viscous glass with a small amount of crystalline material present.

Member 16 (CaO–$2.33B_2O_3$–$0.66SiO_2$): This fused member formed an opaque white glass on top with some clear glass below. Both were apparently true glasses with no evidence of crystalline material present.

Member 21 (CaO–$19B_2O_3$–$4SiO_2$): This fused member also formed an opaque white glass on top with some clear glass below very similar to member 16.

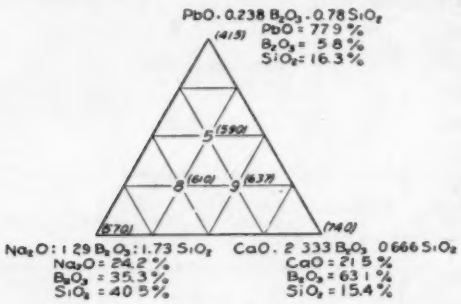

FIG. 6.

Inasmuch as SiO_2 could be added later it was decided to select member 16 as it was highest in lime. It had the following composition: CaO 21.5%, B_2O_3 63.1%, SiO_2 15.4%.

Member 16 was selected as one end member of a triaxial study while the lead borosilicate eutectic (PbO 0.238 B_2O_3 0.78 SiO_2) developed by Lu[5] and the soda borosilicate eutectic (Na_2O 1.29 B_2O_3 1.73 SiO_2) also developed by Lu,[1] were used as the other end members of the triaxial. These are shown graphically in Fig. 6.

The three intermediate members 5, 8, and 9 were made up by blending the end members and a cone deformation study made of them. The results are shown in Fig. 6, the high lead member 5 giving the earliest deformation (590°C), the high soda member 8 being next in order of deformation (610°C), while the high lime member 9 was the most refractory (740°C). This is what might be expected by mixing of end members with wide differences in degrees of deformation, that is, the intermediate members lie within the limits of the various end members. Members 5, 8, and 9 are, no doubt, mixtures and no evidence of deformation eutectic is seen.

In order to increase the refractoriness, durability, and acid resistance of these bases one molecule of SiO_2 was added to each member 5, 8, and 9. They were called 5A, 8A, and 9A, respectively. These members were

[5] *Jour. Amer. Ceram. Soc.*, 9, 29–54 (1926).

made up on a 1000-g. raw batch basis and fritted in a high bauxite crucible. The members were held in the fused state until bubbling had ceased and a fairly clear glass could be drawn from the fusions. The high lead members 5 and 5A were made by first heating the crucible to a bright red heat, then adding the raw material with a scoop and finishing the fritting as rapidly as possible. The actual fritting usually required from one-half to three-quarters of an hour. The frits were quenched in water, dried over a hot plate, and dry ground in a porcelain ball mill to pass a 60-mesh screen.

About 300 g. of each member were then ground for 5 hours with 5% German Vallender clay, and about 66% water. The mixtures were later "set up"[6] by adding 1% borax dissolved in hot water. The members used had the following molecular composition and percentage:

Member 5 (%)			
PbO	38.95		
Na_2O	6.05	0.48 PbO	1.00 SiO_2
CaO	5.38	0.26 Na_2O	1.06 B_2O_3
B_2O_3	27.51	0.26 CaO	
SiO_2	22.12		

Member 8A (%)			
PbO	15.80		
Na_2O	9.75	0.23 PbO	2.24 SiO_2
CaO	4.50	.51 Na_2O	1.32 B_2O_3
B_2O_3	28.50	.26 CaO	
SiO_2	41.50		

Member 5A (%)			
PbO	32.20		
Na_2O	4.85	0.48 PbO	2.00 SiO_2
CaO	4.40	.26 Na_2O	1.06 B_2O_3
B_2O_3	22.40	.26 CaO	
SiO_2	36.20		

Member 9 (%)			
PbO	19.48		
Na_2O	6.05	0.23 PbO	1.97 SiO_2
CaO	10.75	.26 Na_2O	1.58 B_2O_3
B_2O_3	41.83	.51 CaO	
SiO_2	21.90		

Member 8 (%)			
PbO	19.48		
Na_2O	12.10	0.23 PbO	1.24 SiO_2
CaO	5.38	.51 Na_2O	1.32 B_2O_3
B_2O_3	34.88	.26 CaO	
SiO_2	28.18		

Member 9A (%)			
PbO	15.70		
Na_2O	4.95	0.23 PbO	1.97 SiO_2
CaO	8.80	.26 Na_2O	1.58 B_2O_3
B_2O_3	34.20	.51 CaO	
SiO_2	36.40		

These members were tried both as ground coats and cover coat on cast-iron trials. The ground coat was sprayed on and showed very little promise, the enamel crawling considerably. When tried as a cover coat over a commercial ground coat and applied by the dry process, these members all showed considerable promise. The cover coats were dusted or dredged on using a 50-mesh screen.

The ground coat used was a black ground coat and had been previously tried out to satisfaction with some commercial cover coats. This ground coat had the following composition:

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[6] The term "set up" is used to indicate a material that on addition to the enamel prevents the grains of material from settling out.

Frit		Mill addition	(%)
Borax	266	Clay (Fla. kaolin)	6
Flint	164	$MgCO_3$	1
Spar	145	CoO	2
Soda ash	36.5	MnO_2	0.7
$NaNO_3$	26.5	Fe_3O_4	0.2
Fluorspar	35.0	CuO	0.1
MnO_2	11.25	Frit	100.0
NiO_3	6.5	Applied at sp. gr. 1.52; fired 1450–1550°F	
CoO	5.5		

Results of Dry-Process Cover-Coat Test on Black Ground Coat Given Above

They were fired at 1400°F and 1500°F.

Member 5

1400°F: Fair surface, no chipping, no opacity; a second coat gave some opacity.
1500°F: Splendid surface, a little opacity, good enamel; a second coat gave a little opacity and better covering properties.

Member 5A

1400°F: Second coat gave fair enamel, no chipping, no opacity, but rather rough surface.
1500°F: Much better surface than at 1400°, no chipping; second coat showed some opacity.

Member 8

1400°F: Fair enamel, some opacity, no chipping, but rather rough surface.
1500°F: Better surface than at 1400°F; second coat gave fair opacity, but chipped some.

Member 8A

1400°F: Fair enamel, no opacity, no chipping, surface a little rough.
1500°F: Good enamel, surface better than at 1400°F, no chipping; second coat showed a little opacity.

Member 9

1400°F: Poor enamel, some opacity, but poor surface and chipped badly.
1500°F: Surface better than at 1400°F, but enamel chipped badly.

Member 9A

Showed practically no possibility at these temperatures of 1400°F and 1500°F, as the enamel had not matured or vitrified.

These enamels were also used over a commercial ground coat that is being used for cast-iron ware as sinks, water fountains, etc., in the industry. The composition of the ground coat is not known, but it was fired to 1650°F and gives an idea of the behavior of enamels at a higher temperature.

Results of Dry-Process Cover-Coat Test on Commercial Ground Coat Fired at 1650°F

Member 5: Fine enamel, splendid surface, no chipping, some opacity.
Member 5A: Enamel chipped badly, otherwise good.
Member 8: Fine enamel, good surface, considerable opacity and no chipping.
Member 8A: Good surface, little opacity, but second coat chipped badly.
Members 9 and 9A: Good surface and fair opacity but enamel chipped badly.

In both studies the "A" series or high silica showed less opacity than the lower silica members, showing that silica was apparently going into solution in eutectic solvent. The increased chipping with the commercial ground coat is believed to be due in part by the thin coating of ground coat used, giving a poor bond between metal and cover coat.

Action of Various Acids on Enamels

The relative action on a given enamel of different acids and of various strengths of the same acid has been the subject of considerable investigation.[7]

The following acid tests were made in this investigation, using 20% HCl solution:

(1) Drop Test One drop of HCl (20%) was placed on the surface of the enamel and allowed to stand for one minute. It was then rubbed off with a wet sponge and rubbed dry with a clean towel.

(2) Surface Test A surface approximately 1/2 inch in diameter was walled in or surrounded with paraffin. One-half cc. of HCl (20%) was placed in this area and allowed to evaporate at room temperature (21°C) requiring about 10 hours.

(3) Granulated Frit Test Two grams of frit, finer than 60-mesh, were placed in a 400-cc. beaker and 200 cc. of HCl (20%) were added. The contents were stirred thoroughly and allowed to stand for twenty-four hours. The undissolved portion was then recovered on a Gooch crucible. Some of the members formed a gel which could not be filtered and for this reason this method was abandoned as unpractical.

The results of the acid tests were as follows:

Drop Test, Member No.	1400°F	1500°F	1650°F
5	Slightly etched	Slightly etched	Slightly etched
5A	Less than 5	Less than 5	Less than 5
8	Slightly etched	Slightly etched	Slightly etched
8A	No etching	No etching	No etching
9	Slightly etched	Slightly etched	Slightly etched
9A	x	x	No etching

x is immature, not tested.

Surface Test, Member No.	1400°F	1500°F	1650°F
5	Etched through to metal	Etched through to metal	Etched through to metal
5A	" " " "	" " " "	" " " "
8	" " " "	" " " "	" " " "
8A	Etched on surface	Etched on surface	Etched on surface
9	Etched through to metal	Etched through to metal	Etched through to metal
9A	x	x	Etched on surface

x is immature, not tested.

Member 5: Could not be filtered on Gooch crucible as a gel had formed
Member 5A: 56.85% soluble
Member 8: 69.00% "
Member 8A: 50.30% "
Member 9: Could not be filtered on Gooch crucible as gel had formed
Member 9A: 56.50% soluble

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[7] See Bibliography, ref. 40 through 45.

The different tests in general gave the same results. There was no doubt in each case of the high soda, 8A member, as being the most acid resistant, while 9A at 1650°F was next, and 5A was next. There was no evidence of increase in acid resistance by increase in firing temperature.

Inasmuch as member 8A looked to be most promising it was decided to work close to this member and still add more silica. One-half molecule of SiO_2 was added to 8A and this member called 8B. An intermediate member between 8A and 5A plus one-half molecule SiO_2 was made up called 85B. An intermediate member between 8A and 9A plus one-half molecule SiO_2 was made up and called 89B. Members 8B, 85B, and 89B were fused in high bauxite crucibles as explained above in fusions of members 5, 5A, etc. Four intermediate members X, Y, Z, and W were made up by blending 8B, 85B, and 89B as shown in Fig. 7.

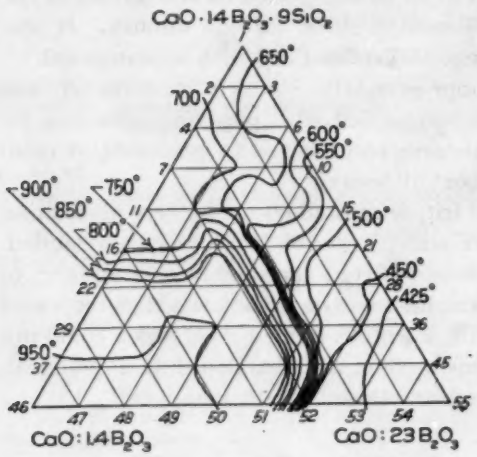

FIG. 7.

The percentage compositions and molecular compositions are as follows:

Member 8B	(%)		
PbO	14.4		
Na_2O	9.0	0.23 PbO	2.74 SiO_2
CaO	4.1	.51 Na_2O	1.32 B_2O_3
B_2O_3	26.0	.26 CaO	
SiO_2	46.5		
	100.0		

Member X	(%)		
PbO	18.1		
Na_2O	7.9	0.29 PbO	2.68 SiO_2
CaO	4.1	.45 Na_2O	1.26 B_2O_3
B_2O_3	24.7	.26 CaO	
SiO_2	45.2		
	100.0		

Member 85B	(%)		
PbO	21.8		
Na_2O	6.8	0.35 PbO	2.62 SiO_2
CaO	4.1	.39 Na_2O	1.19 B_2O_3
B_2O_3	23.4	.26 CaO	
SiO_2	44.0		
	100.1		

Member Y	(%)		
PbO	18.1		
Na_2O	6.8	0.29 PbO	2.62 SiO_2
CaO	5.0	.38 Na_2O	1.32 B_2O_3
B_2O_3	26.0	.32 CaO	
SiO_2	44.1		
	100.0		

Member 89B

	(%)		
PbO	14.4		
Na_2O	6.8	0.23 PbO	2.61 SiO_2
CaO	6.0	.39 Na_2O	1.45 B_2O_3
B_2O_3	28.6	.38 CaO	
SiO_2	44.2		
	100.0		

Member Z

	(%)		
PbO	14.4		
Na_2O	7.9	0.23 PbO	2.68 SiO_2
CaO	5.0	.45 Na_2O	1.39 B_2O_3
B_2O_3	27.3	.32 CaO	
SiO_2	45.4		
	100.0		

Member W

	(%)		
PbO	16.9		
Na_2O	7.6	0.27 PbO	2.65 SiO_2
CaO	4.8	.44 Na_2O	1.21 B_2O_3
B_2O_3	26.0	.29 CaO	
SiO_2	45.0		
	100.3		

These members were all used as cover coats (dry process) on the black ground coat. The results were as follows:

Member 8B, 1650°F: Fair surface, a little opacity, no chipping.
Member X, 1650°F: Good surface, a little opacity, small amount of chipping around edges.
Member 85B, 1650°F: Fair surface, a little opacity, small amount of chipping around edges.
Member Y, 1650°F: Good surface, practically no opacity, considerable chipping.
Member 89B, 1650°F: Fine surface, no opacity, small amount of chipping on edges.
Member Z, 1650°F: Good surface, a little opacity, small amount of chipping around edges.
Member W, 1650°F: Fine surface, a little opacity, small amount of chipping on edges.

The chipping was most pronounced in members Y and 89B or toward high lime content. The chipping appeared to be greater on trials with two coats, suggesting that increased thickness may have had something to do with chipping. This chipping occurred on trials principally after they had been subjected to acid test.

The results of the acid tests were as follows:

Drop test

Member 8B: No evidence of attack
" X: " " " "
" 85B: Slightly etched
" Y: " " more than 85B
" 89B: " " " " Y
" Z: Very slightly etched
" W: " " " like Z

Surface test

Member 8B: Slightly etched; good resistance
" X: Slightly etched; not as good as 8B
" 85B: Etched some; not as good as X
" Y: Etched badly
" 89B: Etched badly; poor resistance
" Z: Etched badly, but better than 89B
" W: Etched slightly; similar to X

The results of these tests pointed conclusively to member 8B, or high Na_2O member as being most acid resistant with X and 85B, or high PbO member next in acid-resisting properties. The high lime, or 89B, appeared to be the least resistant.

Water Solubility

A 10-gram sample was weighed and placed in a glass tumbler and 100 cc. of distilled water were added. The mixture was stirred thoroughly and allowed to stand for twenty-four hours. The mixture was again stirred thoroughly and filtered through porcelain filter tubes using a suction pump. The experiment was carried out at room temperature of 21°C. A blank was also run to test the purity of the water and the possible solubility of the glass tumbler in the water. The following results were obtained:

Blank run	(Grams)
Wt. of Pt dish + residue	41.529
Wt. of Pt dish	41.528
Residue	.001

This represents the amount of glass dissolved in 25 cc. of water and any soluble salts present in the water itself and should be subtracted from the determined weight to get the actual amount of dissolved frit.

Table of Solubility of Frits in Water

Member	Wt. sol. in 25 cc. H_2O (Grams)	Wt. sol. in 100 cc. H_2O	Per cent of original 10 g. sol. in 100 cc. H_2O
5 (high PbO)	0.046	0.184	1.84
5A	.026	.104	1.04
85B	.028	.112	1.12
8 (high Na_2O)	.169	.676	6.76
8A	.040	.160	1.60
8B	.039	.156	1.56
9 (high CaO)	.130	.520	5.20
9A	.104	.416	4.16
89B	.044	.176	1.76

The high lead borosilicate was the least soluble, the high lime borosilicate next, and the high soda borosilicate was the most soluble.

On increase in SiO_2 by one molecular equivalent the solubility in water was decreased. This decrease in solubility was most marked in the high soda member or from members 8 to 8A. With the further addition of one-half molecular equivalent of SiO_2 to member 8A the solubility was decreased a very small amount, 0.04% showing that increase in SiO_2 over one equivalent has very little effect on its solubility in water for this particular high soda member.

Member 85B, which was a new fusion with a composition of one-half member 8A and one-half member 5A plus one-half molecule of SiO_2, had a percentage solubility between 5A and 8A. Member 89B, which was also

a new fusion with a composition of one-half member 8A and one-half member 9A plus one-half molecule of SiO_2, had a percentage solubility between 8A and 9A.

Summary

After the examination, microscopically, of many members high in SiO_2 and CaO, member 16 (CaO 21.5%, B_2O_3 63.1%, SiO_2 15.4%) was chosen as the most practical member available as a means of introducing CaO into the enamel. This member is only a mixture and not a eutectic but it showed, on repeated fusion, complete solution of all constituents, and being high in lime and fairly high in SiO_2 was chosen as the most desirable member.

(a) Brilliance and Smoothness of Surface Developed High lead members were best; high soda members were next; and high lime members were next.

The data obtained is classified as follows:

The lower fusion of the high lead members and their lower viscosity seemed to give these members a more brilliant and smoother surface.

The high soda members are close to high lead members in brilliance and smoothness of surface, and have a deformation point 20°C higher and a slightly greater viscosity.

The high lime members show very little promise, having a considerably higher deformation point (40°C) than the high soda member and a slightly greater viscosity. They were not matured or not enamels at temperatures of 1400 to 1500°F, which are the working temperatures employed.

Smoothness is a very essential property in an enamel coat so that no foreign material is likely to lodge or stick to the surface. This cleanliness of a smooth surface is bound to add to the life and service of an enamel.

(b) Faults in Texture and Bond The tendency to chip was least in the high soda members and greatest in the high lime members. The high lead showed more tendency to chip than high soda members but less than high lime. The tendency to chip was all on the edges of the trial pieces.

The enamels showed no other faults such as blistering, fishscaling, crazing, etc.

(c) Solubility in Water Since practically all enamel frits are quenched in water and since most enamels are applied to the metal in slip form or suspended in water, a knowledge of the solubility of the enamels in water was advantageous.

The high lead borosilicate member was found to be the least soluble, the high lime borosilicate next, and the high soda borosilicate was the most soluble.

(d) Resistance to Acid Attack The high soda members showed the greatest resistance to acid attack. The high lead members were next and high lime members the least resistant to acid attack.

This question of acid resistance is of importance in the manufacture of ware to be used in making of chemicals, explosives, and certain food products. Manufacturers of enameled ware to be used in cooking and for other purposes in which enamel will come in contact with dilute acids are also interested in this problem.

(e) Effect of Additions of SiO_2 to Enamels The enamel as fritted is complete, containing both solvent glass and refractory material, the only addition being a small amount of material such as clay and borax or other salt to "set up" or float the enamel in water in order that it may be applied by the wet process.

Therefore, the addition of SiO_2 or other refractory ingredients to the frit batch is an important consideration in this study and we find that SiO_2 additions change the properties of the base enamels as follows:

In the high lead members the brilliance of the surface was diminished, and at 1400°F the surface was not as smooth. The opacity is also slightly diminished. The tendency to chip is also increased at the higher firing temperature, 1650°F. The resistance to acid is increased considerably with additions of one molecule and with one and one-half molecules of silica.

The high soda members give about the same brilliancy in surface as the high lead members but opacity is decreased considerably with addition of one molecule of SiO_2. The tendency to chip is increased with addition of SiO_2 at the high firing temperature, 1650°F. With the addition of one and one-half molecules of SiO_2 some opacity is obtained but the surface is not as smooth as that of the members lower in SiO_2. The acid resistance is increased to a marked degree and there is no tendency of chipping when fired on the black ground coat.

The high lime members show little promise except when fired at high temperatures, 1650°F, and then their good qualities are overcome by a tendency to chip. The member 89B (formed by mixing the high lime member and the high soda member plus one-half molecule of SiO_2) showed a brilliant and smooth surface with fairly good acid-resistant qualities, but it still had a tendency to chip on the edges of the trials.

On increase in SiO_2 by one molecular equivalent the solubility in water was decreased. This decrease is much more pronounced in the high soda member, being from 6.76 to 1.60%. With further increase in SiO_2 by one-half molecular equivalent a very small decrease in solubility was noted in the high soda member from 1.60 to 1.56%.

On blending high soda with high lead and high lime members and adding

one-half molecule of SiO_2 the solubility approached that of the lowest end member.

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ABSORPTION: ITS RELATION TO DURABILITY[1]

By O. J. Whittemore

ABSTRACT

This paper shows instances of Iowa tile of variance from general classifications, of maximum absorption limits below which building tile are durable against freezing and thawing. Exception is taken to the A.S.T.M. Specification C34–27 as to nomenclature and tests by which tile are classified.

Introduction

Most specifications for hollow building tile are based on those of the A.S.T.M. (C34–27)[2], which classify tile as hard, medium, and soft. Previous investigators have shown a general relation between absorption, strength, and durability. No doubt there is this general relation, and in addition a fairly definite relation for each type of clay. It does seem, however, that the A.S.T.M. nomenclature is incorrect. The terms hard, medium, and soft are not used in reference to comparative hardness such as would be determined by the Brinell method but rather to the degree of firing maturity attained.

The underlying thought was to set standards whereby the durability of tile could be determined under freezing and thawing tests as well as fire-resistance tests.[3]

Types of Clays

Generally speaking, most types of clays have normal firing maturities with coincident physical qualities similar enough to warrant group standards on the basis of absorption and strength. For tile made from a given clay, there is an absorption limit for resistance to freezing. This limit is not the same for all types of clays.

The normal firing maturity for one clay may produce tile with an absorption far below the maximum allowance, while the normal firing maturity of another clay will produce tile having absorptions considerably higher than the maximum allowable percentage.

Firing the tile from some clays beyond normal maturity may increase rather than decrease the absorption or result in warping, blistering, and surface roughness, as is the case with tile from Shale "S."

Tile from Shale "A," fired so as to be merely under the maximum absorption limit, will not be up to normal maturity.

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[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Heavy Clay Products Division.)

[2] The A.S.T.M. tests are strength and absorption; a minimum for strength and a maximum for absorption, thus grouping tile arbitrarily irrespective of type of clay and without further tests to demonstrate exception to the general rule.

[3] Report on Fire Retardant Classifications of Hollow Clay Building Tile Walls, Bureau of Standards, April 19, 1928.

It might be argued that specifications can be written with the inclusion of a provision that in addition to the tile passing the absorption requirements, it must also have been fired to the normal maturity. To be workable, however, specifications have to be written for the layman inspectors who are not familiar with the physical appearances that denote durability of the various tile which they use.

Iowa State Highway Commission Figures

There are a number of instances in Iowa where clays have normal firing maturities with coincident physical qualities varying considerably from the general classification. This paper deals only with tile made from Iowa clays, but doubtless there are similar cases in other states.

The Iowa State Highway Commission tested a total of 5085 samples during a period of three years. Their tests were based on the requirements of the A.S.T.M., C4–24 Specifications, which called for a maximum absorption limit of 7% for extra quality, 9% for standards, and 11% for farm grade drain tile. The average percentage of absorption of specimens successfully passing the freezing and thawing test was adopted as the maximum allowable mean absorption for tile from the plant in question. It should be noted that all of these absorption limits are lower than the present upper limit specified for the "hard" class of building tile according to the A.S.T.M. Specification C34–27.

The variance in normal firing maturities is clearly demonstrated in the results of these many tests. The bulk of the tile tested were for use under contracts calling for farm grade tile.

For five of the manufacturers desiring a rating for their tile in the extra quality class, limits of absorption were established by means of the freezing and thawing test as follows:

	(%)
Shale A	8.6
" B	9.05
" C	11.5
" D	12.5
" E	14.0

These limits were based on the specified 48 freezing and thawing reversals for extra quality tile. (This has since been changed to a requirement of 144 reversals; the thawing is to be done in water at room temperature instead of in boiling water.) It should be noted that three of these established limits are below the arbitrary limit of 12% set in the Hollow Building Tile Specifications for "hard tile," in which class it is assumed that tile should successfully withstand 100 reversals of freezing and thawing.

For the farm grade tile, upper limits for tile from 37 plants were set as follows, grouped into geologically classified types of clays.

(1)	Carboniferous Shale	9 plants	average	14.4%
(2)	Devonian "	5 "	"	18.2 "
(3)	Surface clay	23 "	"	17.3 "

Within group 1 these established limits varied from 11.0 to 16.5%. Within group 2 the limits varied from 16 to 23%, and within group 3 the variation limits were 12 to 23%.

This demonstrated another point, that geological classifications of clays do not indicate close similarity of all physical qualities of the clays included in one geologically classified group.

Within group 2, Devonian shales, an upper limit of 23% was established for farm grade tile from one plant using Shale "S." For tile from this same plant an absorption limit of 21% was set for the standard grade.

Iowa Commission Conclusions

In the conclusions drawn by the engineers in charge of this Highway Commission inspection are the following excerpts:

It will be noted that while in general the absorption increases as the strength decreases, this relation is only general and not at all definite.

There is no constant relation between strength and absorption for any class of material or for the product of any plant.

Absorption is not an absolutely reliable guide as to the ability of a tile to resist frost action. In the case of several plants some samples of tile failed to pass the freezing and thawing test even though the absorption was less than that allowed in Table I (of the A.S.T.M. Specifications).

Absorption test is valuable only as a fairly reliable indication of the ability of tile to resist frost action. Its use without reference to freezing and thawing tests would seem dangerous. It has already been pointed out that the fact that a lot of tile will meet the absorption requirements of Table I does not necessarily mean that the tile will have proper resistance to frost action. We do not feel that the absorption limits given can be relied upon absolutely as assurance that tile will stand up under frost action.

Note As further demonstration that there is a variance of absorption limits for normally fire-matured clay products, tile from Devonian Shale, from the factory using Shale "S," were tested under the 100 reversals of freezing and thawing method. A group of these tile which had an average absorption of 16% by the immersion test or approximately 19 to 20% by the standard boiling test so successfully passed the specified frost test that a new maximum limit of 18% was allowed tile from this factory for use in load bearing and exterior walls of public buildings, and places of employment in one of the midwestern states which rigidly safeguards its citizens from shoddy and unsafe construction.

A possible explanation of the phenomena of highly absorptive tile successfully passing severe frost tests may lie in the fact that its high porosity is due to large pores; large enough so that the pressure exerted by the expanding water on freezing will be relieved by the exudation of small ice

crystals from the pores, and no harm results. This pore structure may be influenced some by the granular structure of the raw clay, or by the manufacturing process, soft mud, stiff mud, or dry press.

There is a real damage resulting from the present specifications as to the absorption limits. Unfair discriminations are made that restrict competition. This in turn causes loss to the ultimate consumers in some territories and to some manufacturers of excellent material which is not acceptable under strict observance of the specifications.

Summary

The writer proposes that the faulty nomenclature of the three classes of structural clay tile be corrected by naming them as follows:

(1) Vitrified, or extra quality, or extra durable
(2) Standard
(3) Soft (in the sense of "easily affected")

Another proposal is that the specifications be patterned after the A.S.T.M. Specification C4–26 for drain tile. The desirable features of this specification are as follows:

(1) For the several classes, maximum absorption limits have been set which are low enough to eliminate all tile of the types of clay having the lowest absorption coincident with normal firing maturity and which would not withstand the required number of freezing and thawing reversals.

(2) In an additional clause provision is made whereby manufacturers may have their tile correctly reclassified into the several groups by the use of the freezing and thawing test using a specified number of reversals of this procedure for each class; the average percentage of absorption of the specimens passing the frost test is adopted as the maximum allowable mean absorption for the tile from that factory.

The number of freezings and thawings to be undergone should be specified for each class and these groups should be established with the idea of differentiating between various degrees of strength and durability of tile. Inasmuch as weathering resistance depends mainly on the kind of clay and the proper degree of firing, freezing tests on well-matured products from a given source would not have to be repeated very often.

Such recognition of the variance in the relation of absorption to durability would be helpful to the industry and to the engineers in charge of the inspection of building material.

Acknowledgment Grateful acknowledgment is made of the data furnished by Bert Myers, Engineer of Materials and Tests, Iowa State Highway Commission.

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CERAMIC ABSTRACTS

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Ross C. Purdy, Editor

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Abrasives

Ancient grinding appliances. ANON. *Abrasive Ind.*, **10** [11], 26 (1929).—A grinding appliance is reproduced from an engraving by Strada made in 1580. E.P.R.

Adopt standard diameters for buffing wheels. ANON. *Abrasive Ind.*, **10** [11], 44–46 (1929).—Eleven sizes were agreed upon as standard diameters for buffing wheels at a general conference held in Washington, Oct. 7, 1929, under the auspices of the Division of Simplified Practice, Department of Commerce. E.P.R.

Polishing data. ANON. *Abrasive Ind.*, **10** [11], 35–36 (1929).—The size of wheels runs generally from 8 to 36 in. diameter. The diameters of wheels in inches and revolutions per minute for polishing wheels and buffing wheels are given in the following table:

Diameter (in.)	Revolutions per min. Polishing wheels	Buffing wheels
8	3700	4000
10	3000	3600
12	2500	3200
14	2200	2900
16	1900	2500
18	1700	2200
20	1500	2000
22	1400	1800
24	1300	1700
26	1200	1550
28	1100	1450
30	1000	1350
32	950	1250
34	900	1200
36	850	1100

Many kinds of polishing wheels are described in detail. Silicon carbide is seldom used as a polishing abrasive because it is almost impossible to make the glue hold it satisfactorily on a wheel. The grit and grade of abrasive to be used depends entirely upon the operation, so it is impossible to set any hard and fast rule. E.P.R.

Cast-iron stove parts polished economically. ANON. *Abrasive Ind.*, **10** [11], 40–44 (1929).—Grinding and polishing operations on cast-iron stoves are described. E.P.R.

Washing of polishing rouge. ANON. *Diamant*, **51** [2], 24–25 (1929).—All polishing rouge, even the finest, must be thoroughly washed before using. Old and modern methods used for accomplishing this are discussed. E.J.V.

Cores cut and shaped by grinding. ANON. *Abrasive Ind.*, **10** [11], 39 (1929).—The Wadsworth Core Machine & Equipment Co., Akron, O., has introduced a portable motor-driven cutting off and coring machine with a capacity of $^3/_8$ to $2^1/_4$ in. It is powered with a $^1/_4$ H. P., 110 volt, alternating current motor. All working parts of the machine are guarded and it is lubricated from convenient points. E.P.R.

High-speed wheels reduce foundry grinding cost. VERNON WELLS. *Abrasive Ind.*, **10** [11], 22–23 (1929).—The article is especially interesting as it gives actual production costs in a malleable iron foundry. The cost of grinding castings with vitrified and high-speed wheels bonded with a synthetic resin, redmanol, are compared and the results favor the new type of wheel. W. points out that the new wheels showed a labor cost reduction of 38% and a wheel cost reduction of 37%. Due to the fact that fewer machines were needed to handle a given output the overhead costs also were reduced. E.P.R.

Coolant pump. ANON. *Abrasive Ind.*, **10** [11], 39 (1929).—The coolant pump described was developed by the Equipment Co., Detroit. It incorporates a new design that makes screens and packings unnecessary. The pump is said to handle a heavy mixture of coolant with grit or chips as effectively as a clean solution. The pump with the motor is $19^1/_2$ in. high and has a 15-ft. lift with a capacity of 50 gal. per min. The pump sets within an $8^1/_2$ in. circle. E.P.R.

British abrasive men hold meeting. ANON. *Abrasive Ind.*, **10** [11], 46 (1929).—Abrasive Industries Association of Great Britain recently held its summer meeting at Bournemouth. E.P.R.

BOOK

Disk grinding booklet. ANON. *Abrasive Ind.*, **10** [11], 34 (1929).—Charles H. Besley and Co., Chicago, are circulating a booklet illustrating and describing Bakelite-bond heavy disks which are mounted on steel backs. E.P.R.

PATENTS

Centerless grinder. WILBUR J. PEETS. U. S. 17,470, Oct. 22, 1929 (reissue). Centerless grinder comprising low- and high-speed wheels adapted to simultaneously press in opposite directions upon a work piece, a work rest for holding work in operative relation to the wheels permitting the work piece to rotate and adjust itself to the opposed pressures of the wheels, automatic means for feeding a work piece to grinding position on the work rest, and automatic means for relatively approaching the wheels to grind the work piece to size and for relatively separating them when the grinding operation is completed to allow the work piece to fall from its support through the space provided by separation of the wheels.

Grinding machine. JAMES N. HEALD AND ALBERT TURNER. U. S. 17,477, Nov. 5, 1929 (reissue). In a grinding machine the combination with a table for supporting the work, of means operable by fluid pressure for reciprocating the table, an electric motor carried by the table for rotating the work, and a common control device for the motor and the fluid pressure supply.

Waterproof abrasive fabric. FRANK JOSEPH CRUPI. U. S. 17,491, Nov. 19, 1929 (reissue). As a new article of manufacture, a sandpaper including a fabric backing, an abrasive grit, and a matrix for attaching the grit to the backing including cellulosic material, a resinous filler, an emollient containing rape seed oil, and a plasticizer.

Waterproof abrasive. HENRY R. POWER. U. S. 17,494, Nov. 19, 1929 (reissue). An abrasive product comprising a flexible backing having an abrasive material attached thereto by a glue, and a coating of a nitro-cellulose composition containing a modifying agent applied thereto.

Abrasive wheel and method of manufacture. HERBERT R. SIMONDS. U. S. 1,732,-287, Oct. 22, 1929. Abrasive wheel composed of material which includes an abrasive substance and a bond comprising compounds of the alkali metals and of the alkaline earth metals, and boric oxide, the bond constituents being present in proportions so controlled that upon fusion into a completed wheel the wheel will have a negligible expansion during use.

Feed mechanism for grinding machines. ALBERT G. BELDEN AND JOSEPH R. WHITTLES. U. S. 1,733,049, Oct. 22, 1929. A cross-feed mechanism for grinding machines comprising a slide, a half nut on the slide, a cross-feed screw engaging the nut, a tumbler gear mechanism having two sets of positively driven gears, one for forward feed and one for reverse feed, manual means to connect the tumbler gear with the screw to move the slide in either direction, and a load and fire mechanism including yieldable means to hold the tumbler gear in or out of driving connection with the feed screw during the normal thrust of grinding.

Centerless grinder. EDWARD SOBOLEWSKI. U. S. 1,733,086, Oct. 22, 1929. Centerless grinding machine comprising a horizontal arbor, a grinding wheel thereon, a table substantially below the grinding wheel and rotatable about a substantially vertical axis which passes substantially through the center of the grinding wheel, an arbor mounted on the table and adapted to swing in a horizontal plane when the table is swung about the vertical axis, a work-supporting and regulating wheel on the lower arbor, means to rotate the regulating wheel slowly and the grinding wheel rapidly to respectively rotate and grind the work, and means to hold work between and in contact with the wheels.

Grinding apparatus. LEWIS R. HEIM. U. S. 1,733,087, Oct. 22, 1929. Grinding wheel adapted to be rotated at a relatively high speed; a regulating wheel adapted to be rotated at a relatively low speed, the wheels being adapted to present adjacent operative surfaces traveling in opposite directions; work supporting means providing a definite axis of rotation for a round body supported thereon and in operative relation to the

wheels, the regulating wheel engaging the body on one side thereof to rotate the body and the grinding wheel engaging the body on substantially the other side thereof and providing an operative surface inclined away from the body for action thereon; means effective to permit movement of the work-supporting means as the regulating wheel engages projecting irregularities in the body thereby to cause a more distant portion of the inclined operative surface of the grinding wheel to become operative upon the body.

Grinding. LEWIS R. HEIM. U. S. 1,733,088, Oct. 22, 1929. Grinding wheel adapted to be rotated at a relatively high speed, a regulating wheel adapted to be rotated at a relatively low speed, the wheels being adapted to present adjacent operative surfaces traveling in opposite directions, a carrier extending between the wheels for supporting work of round section in operative relation to the oppositely traveling operative surfaces of the wheels, means for giving the grinding wheel a reciprocating movement relative to the work, and means adapted to permit a pause to take place at the end of a stroke in the reciprocating movement of the grinding wheel.

Grinding. LEWIS R. HEIM. U. S. 1,733,089, Oct. 22, 1929. Carrier adapted to support thereon work of round section, a grinding wheel rotatable at relatively high speed and positioned on one side of the carrier, a regulating wheel on the other side of the carrier, means including a shaft rotated at relatively low speed for driving the regulating wheel to give the latter a slow surface speed, thereby to control the rotation of the work on the carrier, the wheels being adapted to present adjacent operative surfaces traveling in opposite directions, means driven from the slow speed shaft for giving the grinding wheel a linear movement in the general direction in which the work carrier extends, and means driven from the slow speed shaft for withdrawing one of the wheels from the other to release the work from the grip of the wheels.

Centerless grinder. HERMAN ISLER. U. S. 1,733,094, Oct. 22, 1929. Centerless grinder including opposed grinding and regulating wheels forming a work-receiving throat therebetween, a work rest disposed within the throat, and work feed and ejection mechanism associated with the rest, the mechanism including a transversely reciprocable member having independent means for moving the work into and out of operative position within the throat, means for positively actuating the parts to move the work into operative position and means for resiliently reversely actuating the parts.

Centerless grinding machine. HAROLD W. HOLMES. U. S. 1,733,095, Oct. 22, 1929. Centerless grinding machine comprising a work-regulating wheel and a grinding wheel, means for supporting work therebetween for grinding, means for rotating the regulating wheel slowly and the grinding wheel rapidly, respectively to rotate and grind the work, positively operated precision mechanism for moving the grinding wheel periodically toward and away from the regulating wheel through a predetermined distance, a mechanism constructed and arranged to move work pieces separately and successively into operative relation to the work supporting means and to the regulating wheel and thus into a position for grinding, and means for operating the work moving mechanism cyclically in a properly timed relation relative to the movement of the grinding wheel so as to place a work piece in grinding position when the wheels are separated and upon a subsequent separation of the wheels to permit discharge of the finished work.

Grinding machine. FRED M. KERN. U. S. 1,733,096, Oct. 22, 1929. A precision grinding machine comprising a rapidly rotated grinding wheel, means for holding work rotatively during grinding, power driven means for periodically moving the work and the grinding wheel relatively toward and away from each other through an invariable distance to grind the work to a predetermined size, and means for adjusting the extent of the relative movement.

Centerless grinding machine. HAROLD W. HOLMES. U. S. 1,733,097, Oct. 22, 1929. A centerless grinding machine comprising a slowly rotated work-regulating wheel

and a rapidly rotated grinding wheel, means for holding work therebetween for grinding action by the grinding wheel and for rotation by the regulating wheel, means for moving one of the wheels toward and away from the other, a positively actuated mechanism operating in timed relation with the wheel movement to move a row of axially arranged work pieces progressively forward axially in a path through the grinding zone while the wheels are separated to feed successive work pieces separately to the same position between the wheels for grinding action by the grinding wheel and for rotation by the regulating wheel and then withdrawn, and automatically operated means for replacing ground work when the mechanism is withdrawn.

Centerless grinder. HAROLD W. HOLMES. U. S. 1,733,090, Oct. 22, 1929. Centerless grinding machine comprising a rotatably mounted grinding wheel, a rotatably mounted spindle carrying a work regulating wheel, a driven shaft extending at an angle to the spindle, speed change gear mechanism directly connecting the shaft with the regulating wheel spindle and arranged to rotate the regulating wheel at a slow rate or a normal truing rate, and means for manually controlling the mechanism to secure either of the rates of speed.

Grinder for shouldered work. HAROLD W. HOLMES. U. S. 1,733,091, Oct. 22, 1929. In apparatus of the character described, in combination, a grinding wheel rotatable at a grinding speed, a work rotating wheel rotated at a speed much slower than the the grinding wheel, the wheels being rotated in directions so that the adjacent operative surfaces of the two wheels move in opposite directions, means for holding work of round section between the wheels, the wheels being mounted in peripheral opposition to each other, means mounting the grinding wheel adapted to permit movement thereof in a direction so that the axis thereof moves in a lateral direction into and out of operative relation to the work rotating wheel, and means for effecting the movements of the grinding wheel substantially periodically and in suitably timed relation to permit grinding of the work piece to a predetermined size and thereafter to permit removal and replacement of the work piece.

Centerless grinding machine. SOL EINSTEIN. U. S. 1,733,092, Oct. 22, 1929. In a centerless grinder the combination of a grinding wheel and regulating wheel movable relatively one toward and from the other; a work support and automatic means constructed and arranged to cause the wheels to approach each other with progressive deceleration and then come to rest for an appreciable period with a definite space interval between them, and then to separate the wheels rapidly.

Grinding. CLEMENT BOOTH. U. S. 1,733,093, Oct. 22, 1929. Centerless grinder including, in combination, opposed grinding and regulating wheels and an intermediate work rest, and means for terminally and laterally engaging the work piece to hold the same in predetermined position on the work rest.

Centerless grinding machine. FRED M. KERN. U. S. 1,733,098, Oct. 22, 1929. Grinding machine comprising a grinding wheel, means for rotating the grinding wheel rapidly to grind the work, and means to support a piece of work rotatively in contact with the wheel which permits free relative movement between the grinding wheel and work angularly and laterally of their axes, whereby work having an uneven or nonsymmetrical surface may be ground.

Grinding machine. FRED M. KERN AND ERNEST R. SEWARD. U. S. 1,733,492, Oct. 29, 1929. A grinding machine comprising a grinding wheel and a work-regulating wheel, a work-holding member therebetween, a precision adjusting mechanism adapted to exert a plurality of equal forces simultaneously upon the member to move the same to successive parallel positions in a plane passing through the work between the wheels and means for rotating the grinding wheel rapidly to grind the work and the work regulating wheel slowly to rotate the work.

Gage for disk grinders. GEORGE H. KLIPPEL. U. S. 1,733,687, Oct. 29, 1929. In a disk grinding machine, the combination of a table, a grinder arranged in juxtaposition to the table, a work support for holding a disk to be ground movable toward and from the grinder and a pivoted gage for limiting the movement of a support toward the grinder, the gage being adjustable about its pivot, the work support being pivoted and movable about its pivot toward and from the grinder and the gage comprising an arm extending between the work support and the grinder and having an angular end arranged to engage the pivoted work support and means for holding the gage from pivotal movement.

Abrasive disk. ALBERT J. DOERMANN. U. S. 1,733,723, Oct. 29, 1929. An abrasive disk comprising: a metal backing; outwardly projecting studs fastened in the backing, the inner ends of the studs being cored out; and a layer of a mixture of abrasive material and cement fastened to the face of the backing, the mixture extending into the cored-out ends of the studs.

Centerless grinding. JOHN E. CASTER. U. S. 1,733,863, Oct. 29, 1929. Mechanism including a bed or support, a work rest rising therefrom, a grinding wheel disposed at one side of the work rest having a grooved face, a regulating wheel on the opposite side of the work rest, means for varying the distance between the wheels to vary the width of grinding throat provided thereby, a chute for discharging a work piece into the grinding throat between the wheels in alignment with the groove of the grinding wheel, means for normally holding a plurality of work pieces upward in the chute and means associated with the regulating wheel for releasing individual work pieces from the chute into the grinding throat on each narrowing of the width of the throat.

Fluid-circulating system for grinding machines. ALBERT G. BELDEN. U. S. 1,734,002, Oct. 29, 1929. Grinding machine having a fluid-circulating system comprising a base, a fluid tank, a drive shaft within the base, bearings for the shaft in the base, a centrifugal pump on the drive shaft outside of the tank, conduits to convey fluid from the tank to the pump and from the pump to the grinding wheel and to return the fluid to the tank, and a priming chamber integral with the pump to prime the pump, the conduits being constructed and arranged so as to convey fluid therein to the priming chamber when the operation of the pump is stopped.

Swing-frame grinder. ALBERT G. BELDEN, HOWARD W. DUNBAR, AND CARL G. FLYGARE. U. S. 1,734,003, Oct. 29, 1929. Grinding apparatus comprising a frame, means for suspending the same to permit free movement thereof, a grinding wheel, bearings therefor, means resiliently supporting a bearing on one end of the frame which permits movement of the grinding wheel axis when the wheel is out of balance, a motor on the other end of the frame, and driving connections between the motor and the wheel which serve to rotate the latter for any position thereof.

Segmental abrasive wheel. GEORGE N. JEPPSON. U. S. 1,734,012, Oct. 29, 1929. Grinding wheel unit comprising individual abrasive segments assembled in the shape of an annulus and a supporting member which is rigidly and irremovably united with the annulus to hold the segments in position, the assembled unit forming an independently transportable structure and presenting opposed clamping surfaces engageable by supporting and clamping members.

Grinding-wheel slide and adjusting mechanism therefore. ALDEN M. DRAKE. U. S. 1,734,080, Nov. 5, 1929. In a grinding machine having a frame, in combination, a grinding wheel, a wheel shaft, a slide for the wheel and shaft, the slide being capable of movement in the frame axially of the shaft and having a transverse recess therethrough, manual means to vary the adjusted axial position of the wheel slide, and means to hold the slide in fixed axial position in the frame, the slide having spaced contact studs mounted thereon and positioned in the recess, the manual adjusting means comprising a

lever pivoted at the rear of the wheel slide and extending there-across through the recess to the front of the frame, the wheel slide being engaged by the lever for axial movement thereby manually in either direction when the holding means is released.

Universal radial grinding machine. PATRICK T. LENNON. U. S. 1,734,735, Nov. 5, 1929. An attachment for a grinding machine comprising a longitudinally movable carriage, a rotatable shaft mounted thereon, a pivoted platen carried by the carriage and adapted to rotatably support a cutter having teeth or blades to be ground, means for rotating the shaft and the cutter, and means operatively associated with the shaft and platen for tilting the latter and moving the cutter into and out of engagement with a grinding wheel, the last means including a plurality of detents rotatable by the shaft and each engageable successively with a tooth on the cutter diametrically opposed to the tooth in engagement with the grinding wheel.

Centering device for boring and grinding machines. JOSEPH APPLETON. U. S. 1,734,787, Nov. 5, 1929. A centering tool comprising a head for attachment to a machine for boring or grinding a cylinder, means carried by the head to engage the cylinder on the inside thereof, a plunger arranged in the head to operate the means, a gear arranged in the head to operate the plunger, and means engaging the gear for operating the same from the outside of the head.

Piston-ring-grinding apparatus. GEORGE W. OLSON. U. S. 1,735,333, Nov. 12, 1929. In a grinding machine having a movable work table transversely reciprocable with reference to a fixedly-mounted grinding wheel rotating in a plane at right angles to the axis of the mandrel on which the work to be dressed or ground is placed, a base or frame having slidably mounted thereon a carriage provided with fixed and adjustable centers for supporting a work-carrying mandrel movable (with carriage) to and from the grinding wheel, adjustably connected means for moving the carriage and mandrel so as to bring the work carried by the latter into contact with the grinding instrumentality, adjustable means for limiting the movement to control the thickness of the finished work, adjustable means for driving work by frictional contact with two adjustably mounted rolls of yieldable material whose resiliency offsets or compensates for eccentricity and surface inequalities, means for varying the pressure with which the rolls are made to bear on the work and hold it to the work-supporting mandrel while driving it, but not great enough to distort the work, adjustable work-guiding means for keeping the work in line with the end-wise positioning of the work-holding mandrel, means for locking the adjustable mandrel-supporting center in adjusted position, and means for rotating the adjustably-mounted work-driving friction rolls in association with the means employed for driving the grinding instrumentality and imparting to the work table reciprocating motion parallel with the axis of the grinding wheel.

Process for treating emery wheels. CHARLES L. GEHNRICH. U. S. 1,735,747, Nov. 12, 1929. Process for impregnating emery wheels with rosin comprising the steps of placing a layer of rosin on an emery wheel at ordinary temperatures, heating the two to a temperature above the melting point of rosin, maintaining the temperature at this point until the rosin penetrates the emery wheel and allowing the wheel to gradually cool.

Grinding machine. FRED M. KERN. U. S. 1,735,867, Nov. 19, 1929. A grinding machine comprising a rotatable grinding wheel, a rotatable feed wheel opposed thereto, and means for maintaining a round work piece between and in operative grinding contact with the wheels, the means including a member having a guiding surface in contact with the work piece and so shaped that the points of contact form a substantially unbroken line at a constantly varying angle with a given plane.

Grinding wheel. WILLIAM LEROY BRYANT. U. S. 1,735,891, Nov. 19, 1929. A grinding wheel comprising a hub having an undercut peripheral flange and an undercut clamping member, undercut spacing rings on the hub between the flange and clamping

member forming therewith a plurality of dove-tail grooves, and a plurality of abrasive rings or sections having dove-tail inner portions complemental to and clamped in the grooves.

Abrading device. ELMER C. SCHACHT. U. S. 1,736,056, Nov. 19, 1929. Substantially flexible abrasive element of the class described having a central opening and openings disposed outwardly of the central opening, one edge of each of the outwardly disposed openings being depressed and the abrasive surface adjacent the same being relatively smooth.

Hone or grinder. VICTOR J. EMERY. U. S. 1,736,114, Nov. 19, 1929. Cylinder grinder comprising in combination a cage having longitudinally extending grinding elements, the elements being movable inwardly and outwardly, a driving spindle operatively connected to the cage by a universal joint, the joint being wholly connected at substantially the mid-length of the cage.

Segmental grinding wheel and method of assembling. THURE LARSSON AND HUGO W. H. BETH. U. S. 1,736,161, Nov. 19, 1929. Abrasive wheel comprising in combination a support, an abrasive annulus secured to the support, the annulus and the support being of materials of different coefficients of expansion wherefore temperature changes in the wheel cause movement of the annulus and the support relative to each other, and an elastic medium which serves to compensate for the movement.

Grinding machine. CHARLES H. NORTON. U. S. 1,736,167, Nov. 19, 1929. A steady rest for a grinding machine comprising a stand, a movably mounted work steadying member thereon having an abrading surface adapted to engage the work, and means operable to maintain the desired contact between the surface and the work.

Pressure head for piston-ring grinders. CHARLES E. JOHNSON. U. S. 1,736,199, Nov. 19, 1929. In a device of the class described, means for supporting an article to be worked upon, a pressure head associated with the supporting means and an article thereon, the pressure head comprising a body and a plurality of weights connected to the body and adapted to engage the article at different points, each weight being mounted for independent movement relative to the body and to each other and means for holding the body with the weights in engagement with the article and with its weight free from the weights.

Abrading wheel. ALBERT G. MOSHER. U. S. 1,736,355, Nov. 19, 1929. An abrading wheel for grinding the hubs and backs of pinions or like angularly related parts, having side faces and a V-shaped periphery, one of the angular grinding faces of which V-shaped periphery is formed to engage the back of the pinion and is provided with a series of spaced radial grooves which extend there-across and for a substantial distance into the adjacent side face of the wheel, so that the ends of the grooves in the side face of the wheel terminate at a distance from the back of the pinion, the grooves being of such depth and width and being located at such spaced distances apart so as to produce a current of air, the other angular grinding faces of the V-shaped periphery being disposed at right angles to the first-named angular grinding face and formed to engage the hub.

Abrasive wheels. CARBORUNDUM CO., LTD. Brit. 319,221, Nov. 13, 1929. Abrasive wheels are built up from segmental blocks in one or more circumferential rows, united by elastic cement having a tensile strength equal to or greater than that of the abrasive material, *e.g.*, a synthetic resin to which a solvent and a filler, *e.g.*, plaster of Paris, are added, and which is spread on the contact surfaces of the blocks, air dried, and with the blocks assembled under pressure, hardened by gradually increased heat up to about 165°C. When three or more rows of blocks are used, adjacent and non-adjacent rows have their joints staggered. The cement may comprise polymerized styrol, cellulose acetate, or rubber in place of the resin.

Internal grinding machines. CINCINNATI GRINDERS, INC. Brit. 317,473, Oct. 9, 1929. An internal grinding machine for grinding brake drums, etc.

Surface grinding machines. T. OLDFIELD. Brit. 318,438, Oct. 30, 1929. An inverted surface grinding machine consists of a frame having a work table portion with a ring plate secured thereto, a cup grinding wheel, and a center work table, which is adjustable so as to lie in the plane of the operative surface of the wheel, in order that truly plane work may be produced.

Abrading-tools. BAKELITE CORPORATION. Brit. 319,017, Nov. 6, 1929. Abrasive wheels or paper, and other abrasive tools intended for wet grinding where the temperature of the water may reach 100°C, and the tool thereby loses strength, have the pores filled with wax-like higher chlorinated naphthalenes having a melting point above 100°C. The abrasive tool, which may be bonded with a synthetic resin or other bonds, is heated to about 135°C and is placed in a bath of the impregnating substance maintained at a temperature about 15°C above its melting point, a partial vacuum of about 28 in. of mercury being applied, and the substance then being lowered in temperature nearly to solidifying point. The wheel is then removed and cooled by an air current, excess of the substance being then removed. A suitable substance for the impregnation consists of a mixture of tri- and tetra-chlornaphthalenes having a melting point of approximately 107°C; an alternative consists largely of pentachlornaphthalene which solidifies at about 126°C.

Abrasive wheels. CARBORUNDUM CO., LTD., Brit. 319,200, Nov. 13, 1929. An abrasive wheel, reinforced by metal rings or plates, has expansion joints between the metal and the abrasive in order to compensate for the different thermal expansions of the metal and the abrasive material, respectively, the joints comprising an elastic cement having a tensile strength at least equal to that of the abrasive material.

Art

Inscribed English glasses. FRANK DAVIS. *Illus. London News*, **175**, 778 (1929).—An illustrated account of wine-glasses that depend for their value more on their inscriptions than on graceful design, though this is not lacking. H.H.S.

Stained glass. CLEMENS GAHLEN. *Diamant*, **51** [4], 65–68 (1929).—A discussion of German stained glass industry and artists of the present day is presented. E.J.V.

Modern trends and stained glass. LUDWIG GRIESINGER. *Diamant*, **51** [5], 82–84 (1929).—Modern trend in art and its effect on present-day stained glass work is discussed. E.J.V.

Stiegel glass dish sold at auction. ANON. *Nat. Glass Budget*, **45** [25], 10 (1929).—A large collection of antique house furnishings was recently sold at public auction. What was probably the best price paid for any single piece was for a Sunderland luster creamer, which brought $75. A blue glass Stiegel salt dish brought $45, while a Sunderland luster salt dish was sold for $42. E.P.R.

Faiences of Moustiers. ANON. *Ceram. Verrerie*, **49**, 9 (1929).—History of faience manufacture in Moustiers is treated in detail. The first faience was made there in 1680. A.J.M.

Evolution of styles of porcelain. GUILLAUME JANNEAU. *Ceram. Verrerie*, **49**, 5–7 (1929).—Process of decorating porcelain by use of colors which are fired to a temperature below the softening point of the glaze was first employed in Strasburg in 1730. J. traces the evolution of this type of ware in France. A.J.M.

Ceramics in exhibition of Chinese art in Prussian Academy of Arts, Berlin. ARMIN HAUSLEDEN. *Keram. Rundschau*, **37**, 159–64 (1929).—Dependence of European ceramics

for both motif and method on Chinese ceramics is noted. Photographs of many porcelain objects in the exhibition are reproduced to illustrate this fact. H.I.

Chinese armorial porcelain. FRANK DAVIS. *Illus. London News*, **175**, 470 (1929).—An illustrated account of the 18th Century china made at factories in and near Canton for the table service of well-known families in England. The earliest known piece (reproduced) is a K'ang-hsi jardinière (about 1695) with the arms of Johnson impaling Lovelace. H.H.S.

Bulgarian ceramic art from 9th Century to present. DIMITREFF. *Keram. Rundschau*, **36**, 590–93 (1928). H.I.

Portfolios of color plates showing details of majolica floor tile in the Castle of St. Angelo, Rome. ANON. *Arch. Rec.*, **66** [3], 187–92 (1929).—Plates with description and origin of majolica. E.B.H.

Forgotten art of terra cotta figurines of Zizenhausen. KLAIBER. *Keram. Rundschau*, **37**, 41–44 (1929).—Grotesque figurines which were made in Zizenhausen and had a great vogue in the late 18th and early 19th Centuries are described and illustrated. H.I.

Mosaics of 8th Century found at Damascus. EUSTACHE DE LOREY. *Illus. London News*, **175**, 538–39 (1929).—The remarkable mosaics with which the Byzantine church of St. John at Damascus was adorned when it was transformed into a mosque by the Caliph Walid I (705–715) have been revealed from under whitewash by L., who is director of archæology at Damascus. Six photos. H.H.S.

Individualized table services of difference and distinction. GORDON STERLING. *Crockery Glass Jour.*, **107** [11], 42–43 (1929).—The vogue of colorful furnishings for the home has proved to be remarkably hospitable to innovations; hence the novel idea of making a dining table as gay as a flower bed by means of a china service for every course, each different in color and pattern. This has been received with marked favor ever since its relatively recent introduction. E.P.R.

Correct shape of household goods. M. MENGERINGHAUSEN. *Sprechsaal*, **62** [40], 734–35 (1929).—The faulty design of coffee, tea, and milk containers in dripping during pouring is pointed out and illustrated. The stream of liquid, leaving the spout, must tie in with the curve of the spout and the liquid within the spout must receive a certain minimum acceleration to cause the stream to leave the spout. The following points must be considered: (1) adhesion of liquid to container, (2) form of spout and especially the angle of the end of the spout with the horizontal, and (3) horizontal distance of extreme point of spout from the center of the container as well as the height from the bottom. Further investigations are planned. T.W.G.

Spraying as method of decoration in ceramics. A. HENNIG. *Keram. Rundschau*, **37**, 76–78 (1929); *Ceram. Ind.*, **13** [5], 484–86 (1929).—Spraying on of decoration in earthenware and pottery industry is of advantage because it may be done by more or less unskilled labor. Examples of artistic stoneware, earthenware, and faience produced by this method are shown. H.I.

Ceramics. VALLY WIESELTHIER. *Design*, **31** [6], 101–102 (1929).—The ceramist must know his medium to the full and almost by instinct. Originality must be found by individual experiment after which it may be disciplined by criticism and study of older ceramics. The most fertile ground for ideas is material plus the kick wheel. Real ceramic technique is expressed by a hollow vessel, worked from within to the outside; not modeled in round from lump, whether animal, candlestick, or other article. The problem is to have quantity production without losing freshness, and making forms simple and capable of reproduction without monotony. Illustrated. E.B.H.

Pottery vases as medium for color. DOUGLAS NORRIS. *Arts & Dec.*, **32** [91], 62 (1929).—Simple naturalistic decorations were first applied to pottery. The replacement of these decorations by more formal and defined forms manifested the artistic

growth of the craftsman. Pottery produced in outlying districts retains its unaffected fashion. Due almost entirely to American interest in their productions many rural groups in Europe have developed into factories. A pottery of very naïve flower decoration made in Piediluco, Italy, is known as Paesano or "of the people." The color of the European clay bodies varies with the district. Illustrated. E.B.H.

Pottery exhibit. ANON. *Crockery Glass Jour.*, **107** [11], 52 (1929).—There were three interesting exhibits of art pottery at the New Jersey Flower Show held early in November at Newark, N. J. The Fulper Pottery Co. had an extensive exhibit of Stangl ware in bowls, vases, and off-pieces. The Metropolitan Pottery Co., Inc., displayed a new line of art pottery in addition to their extensive line of florist pots, and the Mountainside Pottery had a varied display of art pieces, some hand made in modern design. E.P.R.

Color specification and prediction. A. C. WATSON. *Amer. Paint & Varnish Mfrs. Assn. Sci. Section Circ.*, No. 341, pp. 978–89 (1928).—Specification is applied to define the color aspect of a pigment only, while prediction means the theoretical calculation of what chromatic results will occur when 2 or more pigments of known chromatic character are mixed in any given proportion. The principles involved in such prediction are sketched with preliminary emphasis upon the necessity of including a statement of the transmission factors of any pigment, alone with the reflection factors in any adequate statement of the pigment's true color character. Reflection coefficients are measured by the use of a differential color rotator and a set of 7 approximate monochromatic color filters. The principles are summarized under 3 heads: (1) the principle of color specification, (2) the principle of pigment mixture involving the effect of absorption upon reflection, and (3) the principle of pigment mixture involving the effect of transmission on the net reflection. Under (1) the reflection-transmission-absorption function is both quantitative and qualitative and no specification of a color material is adequate unless all these factors are all stated. In practical application of the principles discussed, the colorist requires a set of mixture graphs representing the typical results of mixing pigments of various reflection and transmission factors of any pigment. With these factors known reference to the typical mixture graphs should effect great time saving. (*C.A.*)

Comparison of colors: errors and illusions. RENÉ TOUSSAINT. *Chimie & ind.*, **21**, 924–30 (1929).—A brief discussion of the difficulties inherent to matching of colors and of the use and advantages of the photocolorimeter for this purpose. (*C.A.*)

Illustrations of lighting fixtures in modern style. ANON. *Arts & Dec.*, **31** [5], 74–75 (1929). E.B.H.

British Museum Quarterly. Vol. IV, No. 1. BRITISH MUSEUM. Oxford University Press, London, 1929. Price 2s.—Illustrations include a glazed schist statuette from Egypt, and Persian pottery of the Bronze Age and of the 13th Century A.D., showing Chinese influence. H.H.S.

New treasures from Tutankhamen's tomb. HOWARD CARTER AND HARRY BURTON. *Illus. London News*, **175**, 576–79 (1929).—Fourth series of photographs of objects found in the room known as the Annexe. (For previous abstract see *Ceram. Abs.*, **8** [11], 792 (1929). H.H.S.

Unique discoveries in Syria. F. A. SCHAEFFER. *Illus. London News*, **175**, 764–67 (1929).—An expedition sent by the Institut de France to north-west Syria has made sensational discoveries of an unknown language, royal archives, tombs, and art treasures of the 13th and 14th Centuries B.C. 25 photos. H.H.S.

Treasures from Ur. C. LEONARD WOOLLEY. *Illus. London News*, **175**, 504–507 (1929); see *Ceram. Abs.*, **8** [5], 317 (1929). H.H.S.

BOOKS

Aboriginal Society in Southern California. W. D. STRONG. 358 pp. Univ. of

California Press, Berkeley, 1929. Price $4.50. Vol. 26 of the Univ. of Calif., Dept. of Anthropology Publications. H.H.S.

History of British and American Etching. JAMES LAVER. 84 plates. Ernest Benn, Ltd., London, 1929. Price 3 guineas. Reviewed in *Illus. London News*, **175**, 602 (1929).—This decade is said to exhibit a renaissance of etching. H.H.S.

PATENTS

Manufacturing tile. EDWIN H. WHITE. U. S. 1,727,580, Sept. 10, 1929. Method of forming tile having decorative surface designs comprising arranging a series of layers of plastic cements of different colors in a form and forcing portions of the cements from the different layers to penetrate through one another to the bottom of the tile while in a soft plastic condition by imparting rapid vibration to the form carrying the cements.

Design for bottle. HARRY KAHANOWITZ. U. S. 79,721, Oct. 29, 1929; GEORGE F. GALLAGHER. U. S. 79,924 and U. S. 79,925, Nov. 19, 1929; LOUISE PESZYNSKA. U. S. 79,935, Nov. 19, 1929.

Design for dish. OTTO BERGNER. U. S. 79,917, Nov. 19, 1929.

Design for flower bowl, etc. THOMAS CLARENCE HEISEY. U. S. 79,716, Oct. 29, 1929.

Design for glass tray, etc. JESS CLAIR KELLY. U. S. 79,725, Oct. 29, 1929.

Design for jar. WALTER D. TEAGUE. U. S. 79,944, Nov. 19, 1929.

Design for lavatory. EARL G. WATROUS. U. S. 79,862, Nov. 5, 1929.

Design for plate. HARRY BARKBY. U. S. 79,618, Oct. 22, 1929; HAROLD TAYLOR ROBINSON. U. S. 79,668 and U. S. 79,669, Oct. 22, 1929; WALTER STANLEY WOODMAN. U. S. 79,777, Oct. 29, 1929; FRANK GRAHAM HOLMES. U. S. 79,816, Nov. 5, 1929; THOMAS CLARENCE HEISEY. U. S. 79,885, Nov. 12, 1929.

Design for chimney cap. OSCAR S. WINKLER. U. S. 79,775, Oct. 29, 1929.

Design for goblet. FERDINAND SCHMIDT. U. S. 79,778, Oct. 29, 1929.

Design for tumbler. DAVID FISHER. U. S. 79,881, Nov. 12, 1929.

Design for toby jug. JENNINGS HOOD. U. S. 79,928 and U. S. 79,929, Nov. 19, 1929.

Ornamenting glass. W. H. STEELE. Brit. 317,587, Oct. 9, 1929. Relates to plate, sheet, or other glass of the kind having ornamental or other designs, which are produced by photography, printing, or otherwise on a coating or sheet of gelatine, and consists in applying the designs to the gelatine coating before the gelatine is applied to the glass. The design may be applied by means of a photographic transfer, or by means of the Bromoil process, one bromide print being utilized to produce several impressions by being suitably oiled between impressions. A protective coating of paint, bronze powder, or cellulose solution may be applied to the gelatine. Two glasses, each having a gelatine coating bearing a design, may be combined together, the gelatine surfaces being placed in contact. The process may be applied to glass having a curved formation or an uneven thickness, and is suitable for ornamenting glass table-tops, trays, windows, facias, etc.

Cement, Lime, and Plaster

Constitution of hydrated Portland cement. G. ASSARSSON AND N. SUNDIUS. *Concrete*, **35** [4], 101–104 (1929).—A report of the Swedish Geological Society covering microscopic investigations of the constitution of Portland cement clinker and its chemical reactions during hardening. In hydrated cement a large amount of non-hydrated clinker is uniformly distributed in the dense hydrated cement mass. These clinker grains are mostly disilicate. Trisilicate also occurs but in larger fragments enveloped by clear zones of hydrosilicate. Grains of clinker aluminate are practically absent. The CaOH is well crystallized. It fills out the small spaces between the hydrated and

unhydrated clinker grains. The main part of the hydrated cement is composed of amorphous silicate product. Hardening consists in hydrating the aluminates and their transformation into hydro-trialuminate, a decomposition of most of the ferritic substance, and a splitting-off of one of the CaO molecules from the trisilicate. The ferritic substance is not very easy to hydrolize but its amount is small. The disilicate in the clinker is but little affected. The further hydrolysis of the still average disilicate complex silicate proceeds very slowly, each increase in water content causing a continued hydrolysis of the silicate complex and a generation of more CaOH. That cement can exist unchanged for many years, even when immersed in water, is wholly due to the density of the structure and of the hydrosilicate. E.A.H.

Crystal structure of tricalcium aluminate. F. A. STEELE AND W. P. DAVEY. *Jour. Amer. Chem. Soc.*, **51** [8], 2283–93 (1929).—The tricalcium aluminate was prepared by mixing and grinding a mixture of CaO and Al_2O_3 in the molecular ratio of three to one. The mixture was then heated in air to 1350 to 1450°. The material at this temperature sintered into a light friable lump. X-ray diffraction patterns of the powdered substance, using molybdenum K alpha radiation, showed strong lines characteristic of a body-centered cube, α = 3.812 Å, superimposed on a weak pattern of CaO and numerous additional faint lines. By means of the petrographic microscope it was determined that other calcium-aluminum compounds were present. For crystallographic purposes the formula of tricalcium aluminate was determined to be $9\,CaO{\cdot}3Al_2O_3$. Tricalcium aluminate has no grouping which would justify its name. From its crystal structure it appeared to be a mixed oxide and not a salt. It is distinctly different from solid solutions or mix-crystals. The type of crystal structure probably belongs to the classification known as mixed ionic compounds. R.G.M.

Hydration of aluminates of calcium. II. Hydration products of tricalcium aluminate. T. THORVALDSON, N. S. GRACE, AND V. A. VIGFUSSON. *Can. Jour. Research*, **1** [3], 201 (1929).—Further studies on the isometric form of hydrated tricalcium aluminate are reported. These include methods of preparation, crystalline forms, X-ray diffraction pattern, and determination of solubility and density. The products formed when the hexagonal form of hydrated tricalcium aluminate is dehydrated at definite vapor pressure of water at 21 °C were studied. The density, refractive indexes, heats of solution in $HCl{\cdot}200H_2O$, and X-ray diffraction patterns of several probable hydrates were determined. The experimental evidence given indicates that hydrates of $3CaO{\cdot}Al_2O_3$ having 6, 8, $9^1/_2$, $10^1/_2$, and 12 mol. of water are formed, but that the water in excess of 8 mol. is very loosely held and that its removal does not materially affect the crystal structure. The exact composition of some of the higher hydrates requires confirmation. For Part I see *Ceram. Abs.*, **8** [12], 863 (1929). W.L.

Composition and properties of so-called natural cements. HAEGERMANN. *Tonind.-Ztg.*, **53** [55], 981–85 (1929). F.P.H.

Studies on action of sulphates on Portland cement. I. Use of expansion method in study of action of sulphates on Portland cement mortar and concrete. T. THORVALDSON, D. WOLOCHOW, AND V. A. VIGFUSSON. *Can. Jour. Research*, **1** [3], 273 (1929).—This paper describes methods employed in use of expansion measurements as means of studying action of sulphates on Portland cement, and on Portland cement mortars. Experimental data are given dealing with the reproducibility of expansion measurements and the relation between expansion and loss of tensile strength of mortars. Results obtained with standard sand mortars and graded sand mortars of varying richness of mix prepared from cements which differ in their resistance to sulphate action are presented. W.L.

Effect of temperature on setting times of cements and on strength of cement mortars and concretes. W. N. THOMAS AND N. DAVEY. *Dept. Sci. Ind. Research* [Bldg.

Research Special Rept.], No. 13 (1929).—A summarized review is given of the literature on the subject of the effects of temperature on the setting times of cements and on the strengths of mortars and concretes. Details are given of experimental work carried out by the authors with the view of elucidating certain disputed points. The report includes the field of Portland cements, rapid hardening Portland cements, and aluminous cements. An extensive bibliography is appended. W.L.

Effect of calcium chloride on some of the physical properties of Portland cement. S. UCHIDA. *Concrete*, **35** [4], 112–14 (1929).—Calcium chloride used within certain limits accelerates the setting and hardening of cement and increases its strength. E.A.H.

Tensile autogenous healing of Portland cement mixtures. H. G. GILKY. *Engineering*, **128** [3325], 450–52 (1929).—Healing is attributed to fresh crystalline growth resulting from the continued normal curing processes rather than to any redeposition of soluble salts as was suggested in former papers. Tests made on Portland cement mixtures are described which support the above view. Healing action is explained by the examination of crystal structure which revealed the presence of calcium silicate, hydrates of calcium, and two forms of calcites. Some possible applications are also mentioned. A.A.

Deterioration of concrete in hydraulic structures. ALEX EKWALL. *Concrete*, **35** [4], 21–22 (1929).—A summary of a preliminary report made by the Swedish Royal Board of Waterfalls. Deterioration has been found both in structures exposed to clean melting water from the mountains and impure river water. Without exception deterioration occurs where one side only is exposed to water pressure. Variations in the characteristics of river waters are comparatively small and not the cause for the defects. Solubility of CaOH seems to be the main cause of the deterioration. With percolating water this goes on until complete breakdown of cement occurs. E.A.H.

Artificial marble and scagliola. CLIFFORD WAYNE SPENCER. *Arch. Eng. Business*, **11** [2], 557–64 (1929).—Artificial marble is produced by mixing superfine Keene's cement with the proper amount of mineral coloring matter, of proved permanence, to give a ground color to match that of the sample of natural marble which is to be duplicated. Skeins of silk fiber are then soaked in water in which has been ground mineral color to match the desired veining. This color-soaked silk is spread out on a smooth counter in such a way that some strands remain bunched together while others spread out thinly over what is to be the surface of the marble, the effect being remarkably similar to natural marble veining. E.P.R.

Cement reference laboratory. ANON. Bur. Stand., *Tech. News Bull.*, No. 150, pp. 93–94 (1929).—For the guidance of commercial cement testing laboratories a list of proposed tolerances on apparatus under which the Cement Reference Laboratory at the Bureau of Standards is operating at present is listed. R.A.H.

Canadian gypsum industry. R. M. SANTMYERS. *Can. Chem. Met.*, **13** [11], 19–23 (1929); for abstract see *Ceram. Abs.*, **8** [12], 866 (1929). E.J.V.

PATENT

Plaster and process of controlling setting and expansion of setting, an accelerator and expansion controller therefor, and process of making such controllers. JOHN D. WIGGIN AND MATHIAS M. REMMES. U. S. 1,732,737, Oct. 22, 1929. Process of making a plaster composition whose setting and expansion can be controlled, consisting in forming an accelerator and expansion controller by saturating hot water with boric acid, and then mixing the water with a mass of plaster in such amounts that the water is insufficient to solidify the mass, and thereafter mixing the accelerator and controller with other plaster.

Enamels

Silicate of soda in enamel mixes. ANON. *Ceram. Ind.*, **13** [5], 471–72 (1929).—It has lately been found advantageous to use silicate of soda in enamel mixes for sanitary ware because it is thus possible to make enamels which work satisfactorily at lower temperatures than enamels of the same composition in which silica and soda are introduced separately as sand and soda ash. Experience has shown that the enamels made with silicate yield lustrous coatings much more resistant to acid than the lead enamels, but which, at the same time, can be worked at moderate temperatures. The rate of production through the factory is probably a little slower than when lead is used, but the cost for materials is less and the end product is said to be better. Similar advantages are obtained by using silicate of soda instead of soda ash and silica in lead-bearing enamels. F.P.H.

Flotative for enamels. ANON. *Ceram. Ind.*, **13** [5], 477 (1929).—A new flotative for enamels has been found and developed in a material by the name of ammonium algernate. This material is made by treating seaweed with ammonia, resulting in a green paste which has a very offensive odor. When using this material, a close watch must be kept on the water contents and the enamel must be milled for a short time before the algernate is added. To obtain the best results, it is suggested to mill the enamel as fine as permissible. F.P.H.

Inhibitors in pickling process. ALLISON D. TURNBULL. *Iron Age*, **124** [10], 598–600 (1929).—Inhibitors are used to prevent reaction between acid and metal and to reduce evaporation from surface of bath. Pickling bath should be heated indirectly. If steel is overpickled, iron corrodes and hydrogen is formed. If inhibitor is used, water is formed. Inhibitors are essentially organic compounds such as carbohydrates. Nascent hydrogen tends to react with carbohydrates and the metal cannot dissolve. The amount of inhibitor used should decrease with increasing age of the pickling solution. E.C.C.

Testing enamels. ANON. *Emaillewaren-Ind.*, **6** [39], 317–18 (1929).—Kinzie's method of testing enamel by a falling steel ball within a pipe (to hit the identical spot) was tried out. It was found that the method is satisfactory for sheets up to 1 mm. thickness using a ball of 30 mm. diameter and weighing 100 g. if the holes through the pipe for holding and adjusting the height of the ball are spaced at intervals of 10 cm. The resistance to such hammer blows depended primarily upon the thickness of the sheet metal and secondarily upon the kind of enamel; by using the identical enamel on a metal of 2 mm. thickness no failure was evidenced after 300 impacts. A ball of about 40 mm. diameter would be required. T.W.G.

Enameling developments. F. M. BURT. *Ceram. Ind.*, **13** [5], 482–83 (1929).—The following developments in the enameling industry in the last year are discussed: (1) advancement in projected use of continuous enameling furnaces and handling equipment up to and away from firing equipment; (2) cutting of cycle of production in several plants, already installed, being installed and planned, utilizing all types of conveying equipment; (3) enamel development in acid resistance, greater frit opacity, and production under closest control; (4) colored enamels in different blends, largely in higher grades of kitchenware, bath, toilet equipment, and stoves; (5) continued installation of enameling divisions in a wide variety of manufacturing plants; (6) continued frank dissemination and exchange of enameling information, even among close competitors and greater freedom in plant visitation; and (7) widening sources of supply for better grade steel enameling stocks adaptable to all manner of difficult drawing. F.P.H.

Practical differences between dipping and spraying methods in enamel industry. ANON. *Glashütte*, **59** [39], 680–81 (1929).—A discussion of methods. L.T.B.

Hints for successful spraying. G. H. BUZZARD. *Enamelist*, **6** [12], 11–13 (1929).—Successful application of vitreous enamels by the spray process requires a minimum air pressure of 75 lbs. at the spray gun, proper feed of enamel to the gun, frequent inspection of equipment and adequate exhaust fans for the spray booths. G.H.McI.

Removal of defective enamel. ANON. *Glashütte*, **59** [39], 705–706 (1929).—Methods for the removal of defective enamel from surfaces include: (1) cracking away by hammering; (2) heating and quenching; (3) melting; (4) sand-blasting; (5) solution in caustics under pressure; (6) solution by the use of fluorine; and (7) by a new method which consists of treatment of the surface with dilute sulphuric acid followed by treatment with 10% soda solution whereupon the enamel may be removed readily. L.T.B.

Manufacture of enameled signs. W. LINKE. *Emaillewaren-Ind.*, **6** [39], 318–20; [41], 337–38 (1929).—Details of manufacture. T.W.G.

Electrically heated enameling furnaces. ANON. *Glashütte*, **59** [39], 706–707 (1929).—The advantages of an electrically heated furnace are simplicity and compactness in construction, accurate control of temperatures, and subsequent improvement of the quality of the product manufactured. On the other hand, the expense connected with their installation and operation may overbalance all advantages and prohibit their use. A table of comparative costs of operation of furnaces heated by various methods is included. L.T.B.

Savings effected by continuous enameling furnaces. ANON. *Enamelist*, **6** [10], 8–12 (1929).—Intangible savings are credited to smaller floor space required and the improved quality of the ware due to the annealing action of the furnace. Tangible savings are gained through lowered labor costs, elimination of trucking, lowered fuel costs, and decrease in amount of rejected work. G.H.McI.

Rubber-lined pickling tanks. ANON. *Ceram. Ind.*, **13** [5], 477 (1929).—New development in pickling tanks is a rubber-lined container installed at the Cribben and Sexton Co., Chicago. This tank has a 500-gallon capacity and has thus far given satisfactory service for 7 months. An ordinary unlined cypress tank ended its usefulness in about $3\frac{1}{2}$ months. The new tank is 8 ft. long, 3 ft. wide, and 3 ft. deep, and is lined with pure gum rubber, $\frac{1}{4}$ in. thick, vulcanized in one unit. This rubber lining extends also over the top of the container and about 2 in. down the outer side of the wall. The bottom of the tank is fully protected by ordinary lumber, as is also the top of the tank walls. Eight guards, made of 2 in. steel completely enclosed in gum rubber, extend to the bottom of the tank. F.P.H.

Pickling. ANON. *Emaillewaren-Ind.*, **6** [42], 344–45 (1929).—American lapitolith in place of the usual ground coat was found to be unsatisfactory. T.W.G.

Wage problems in enamelware plants in Germany and U.S. ANON. *Emaillewaren-Ind.*, **6** [39], 320–21; [40], 328–29; [42], 345–46 (1929). T.W.G.

German Foundry Exhibition. ANON. *Iron Trade Rev.*, **85**, 976–77 (1929).—Fifth exhibition organized by the Union of German Iron Founders was held at Düsseldorf, Sept. 1929. The standardization has now reached foundry practice. Cast iron is classified into 4 grades of German standard (DIN). The design of castings has also come under regulation. H.H.S.

European iron for enamelware. ANON. *Iron Age*, **124** [7], 412–13 (1929); Reprinted from, *La Revue de Fonderie Moderne*, July, 1929.—An iron containing no free carbon may be enameled satisfactorily. Carbon plays an important part in reducing enamel oxides. It causes the enamel to become transparent, uneven, and otherwise defective. Oxides of zinc are particularly affected by graphite carbon. 3.7% is the limit of C in iron castings. Use of carbonaceous materials should be avoided in molding. E.C.C.

Pickling steel for vitreous enameling. F. G. JAEGER. *Metal Cleaning and Finishing*, **1** [3], 299–302 (1929). (*C.A.*)

PATENTS

Producing lepidolite enamel. CARL TRENZEN. U. S. 1,734,698, Nov. 5, 1929. Method of enameling a metal article which consists in applying a coating of powdered lepidolite directly in contact with the metal, and thereafter subjecting the article to a baking temperature.

Selectively controlling metal-pickling baths. JAMES H. GRAVELL. U. S. 1,736,118, Nov. 19, 1929. Method of reinforcing the selective control effects of thioamides in a pickling bath which comprises causing a thioamide in the pickling bath to exert its selective control effect in the presence of a dispersing substance that will reinforce the selective control effect of the thioamide.

Treating metal to remove scale. CHARLES FISCHER, JR. AND LOU A. STEGEMEYER. U. S. 1,736,282, Nov. 19, 1929. Process of inhibiting the action of a scale removing bath of mineral acid upon the metal from which the scale is to be removed, the process comprising introducing into the bath a mineral oil sulphonic reagent of the class recovered from the operation of refining mineral oil to produce relatively white oil.

Enameling furnace. ALLGEMEINE ELEKTRICITÄTS-GES. Ger. 480,718, Mar. 22, 1927. (*C.A.*)

Fire chamber for enameling furnace. ALLGEMEINE ELEKTRICITÄTS-GES. Ger. 480,719, Oct. 26, 1927. (*C.A.*)

Glass

Antique glasses. BERNHARD NEUMANN. *Z. angew. Chem.*, **42** [33], 835–38 (1929).—Analyses are given of some glasses of the ancient Egyptians, Babylonians, and Romans dating from about 1400 B.C. There is included a discussion of the significance of the various components found in them. L.T.B.

Signal green and absorption of copper oxide in various glasses. E. ZSCHIMMER. *Sprechsaal*, **62** [10], 169 (1929).—In compliance with the German navy standards relative to permeability of light in reference to Z.'s previous article (*Sprechsaal*, **59**, 818 (1926)), the coefficients of permeability are corrected as follows: For blue with a wave-length of 444$\mu\mu$ the lower limit of the coefficient is 0.29 (stated before 0.28), for green with a wave-length of 528$\mu\mu$ the lower limit of the coefficient is 0.30 as before, and for red with a wave-length of 656$\mu\mu$ there is an upper limit of 0.025 (stated before 0.020). According to the navy yard no importance is attached to the wave-length in judging the color of signal green but the curve of permeability is of importance. T.W.G.

Determination of strain in glass by a radiation method. L. R. INGERSOLL. *Jour. Amer. Ceram. Soc.*, **12** [12], 756–59 (1929).—Method of determining strain in glass by a radiation measuring instrument is given and its adaptability if developed on a commercial basis.

Correction on "Relationship between chemical composition and thermal expansion of glasses." S. ENGLISH AND W. E. S. TURNER. *Jour. Amer. Ceram. Soc.*, **12** [12], 760 (1929).—This is a correction by the authors of thermal expansion factors for zinc oxide, alumina, and baryta to 2.1, 0.42, and 4.2, respectively.

Density factors for soda-lime glasses. S. R. SCHOLES. *Jour. Amer. Ceram. Soc.*, **12** [12], 753–55 (1929).—Density factors based on oxides are criticized. A series of glasses are analyzed, compositions calculated in terms of $Na_2O \cdot 2SiO_2$, $CaO \cdot SiO_2$, $MgO \cdot SiO_2$, SiO_2, and Al_2O_3. Factors for the three assumed compounds are calculated from three of the glasses, factors for SiO_2 and Al_2O_3 as given by other investigators adopted, and the factors applied to the calculation of densities for the series of glasses. The re-

sults show close agreement with measured densities for six glasses analyzed and one described in the literature.

Absorption of light in colored glass. R. ZSIGMONDY. *Glass Ind.*, **10** [11], 262–65 (1929); translated by S. R. Scholes from *Ann. Physik*, **4** [4], 60 (1901).—Glasses of definite types whose compositions are given were melted in an oxidizing flame, together with determined amounts of colored oxides. The extinction coefficients of these glasses were measured with a Glan spectrophotometer, and after reduction to a comparable basis, were completed in curves, which are reproduced in the article. The oxides used include chromium, copper, cobalt, nickel, manganese, iron, and uranium oxides. The various colored glasses are discussed. An examination of the curves shows that with the presence of equal amounts of coloring oxides in a unit volume of glass, the cobalt oxide would act as a stronger coloring material than the other oxides and that iron oxide possesses a very light coloring power. This is a condition of the highest importance, considering the wide distribution of these substances in nature. E.J.V.

Glasses containing rare earths. WEIDERT. *Z. angew. Chem.*, **42** [33], 843–44 (1929); for abstract see *Ceram. Abs.*, **8** [11], 800 (1929). L.T.B.

Comparative studies of resistivity of Russian and foreign chemical glassware. M. A. BESBORODOV. *Keram. Rundschau*, **37**, 121–23, 166–68 (1929).—Methods and results of treating resistant laboratory glassware with hot KOH, NaOH, K_2CO_3, Na_2CO_3 and Na_2HPO_4 are described. Russian glassware is comparable with non-Russian in its resistance to attack. In general, the higher the Al_2O_3 content (up to a maximum) the greater the resistance to Na_2CO_3 solution and the higher the CaO content the greater the resistance to NaOH solution. The replacement of B_2O_3 by Al_2O_3 gives the glass a better resistance to water and Na_2CO_3 solution and lowers the resistance to NaOH solution. H.I.

Sulphate of Karabugas in Russian glass industry. L. N. MURAWLEFF AND P. N. GRIGORIEV. *Keram. Rundschau*, **37**, 4–5 (1929).—Natural Na_2SO_4 in the form of mirabilite is thrown up on the flat shores of the Karabugas bay on the Caspian Sea during the severe winters and is crystallized in a very pure form during the hot rainless summers. In purity it excels the best manufactured product but its cost is high due to poor organization, poor technique in recovering the salt, and high labor costs. The sulphate is particularly suitable for glass manufacture due to its low content of iron and free SO_3. H.I.

Composition, structure, and origin of stalactites in burners of glass furnaces. D. S. BELIANKIN AND M. A. BESBORODOV. *Keram. Rundschau*, **36**, 573–76, 596–99 (1928).—Stalactites which had formed on the silica brick partition dividing the gas channel from the air channel in the port of a pot furnace were analyzed chemically and petrographically. The stalactites contained: SiO_2 82 to 90%, CaO 6 to 8%, alkalis 2 to 4%. Petrographically the stalactites were composed of intergrown masses of tridymite and pseudo-wollastonite. It is concluded that the pseudo-wollastonite contains other metasilicates in solid solution and that the constituents of the stalactites were obtained from batch constituents which were deposited as dust on the silica brick. H.I.

Chemism of melting of soda-borosilicate glass. M. A. BESBORODOV AND M. F. SHOOR. *Glass Ind.*, **10** [11], 257–61 (1929).—Melting glass, which is one of the most important processes in the manufacture of glass, could be rationalized only if it were known to a sufficient degree how this process is being carried out from the physical and chemical point of view. The rationalization of glassmelting must therefore begin with a scientific basing of the process. The proximate problem in glass technology undoubtedly is the study of the conditions of reaction of various components of the batch at different temperatures and obtaining with them a homogeneous melt called glass. A few works dealing with this subject are briefly discussed. In this investigation,

in an attempt to study the chemism of melting of one of the glasses used in glass manufacturing, a soda-boric acid-silica glass consisting of 25% B_2O_3, 65% SiO_2, and 10% Na_2O, was selected. The composition of the batch was calculated on the basis of the proposed composition of the glass and of the materials used for the melting and was as follows: quartz 65.00 parts, soda 17.10 parts, and boric acid 14.28 parts. The meltings, eight in number, were carried out in a platinum crucible in a laboratory electric furnace and in each case the temperature was held constant for an hour, the eight temperatures being respectively, 500, 600, 700, 800, 900, 1000, 1100, and 1200 °C. These meltings were followed by fractional chemical analysis of the melts, and showed that reaction between different components of the batch sets in below 500 °C and is completed on the whole at 900 °C. The components which enter into reaction first are soda and boric acid; they dissociate and at 500 °C form a compound. No traces of undecomposed soda are to be detected in the melt at 500 °C. The reaction of the components of the batch begins far below the melting point of the most fusible of them. At 700 °C silica begins to take part in the reaction. The formation of silicates is most intense at 700 to 900 °C. Below 700 °C apparently no silicates are formed. The temperature interval between 900 °C and 1200 °C is characterized by a certain quantity of previously formed silicates. Between 1100 °C and 1200 °C the melt becomes a vitreous transparent mass. E.J.V.

Sealing glass to metal. ANON. *Glashütte*, **59** [38], 678–79 (1929).—In the construction of an aeronautical instrument it was necessary to have a water-tight seal between the glass of the instrument and the metal casing. Various methods of obtaining such seals are discussed. L.T.B.

Prismatic window glass. ANON. *Engineering*, **128** [3325], 447 (1929).—The Holophane Co., Ltd. (England), has designed a prismatic glass intended for use in the natural lighting of such rooms as only receive their sunlight and skylight from restricted and high angles. Tests show that it transmits 73% of the incident light from a restricted sky subtending an angle of 45° from the vertical. The new glass alters the angle of maximum illumination from 35° to between 55° and 70° from the vertical with very little reduction in intensity. To get more even illumination emergent rays are widely diffused by suitably curving the face of the prism. A.A.

Optical heterogeneity of fused quartz disk. L. W. TILTON AND A. Q. TOOL. Bur. Stand., *Jour. Research*, **3** [5], 619–28 (1929).—In preparing a refractive index standard of fused quartz having the form of a 60° prism, it was considered advisable to carefully investigate the optical density of this glass since appreciable variations might be present because of nonuniform heat treatment or other factors. With this in view the standard, together with nine small auxiliary prisms, was cut from a disk 52 mm. in diameter and 13 mm. thick. The indexes of these prisms were measured, for 5 different wave-lengths, to an accuracy of a few units in the sixth decimal place. As a result the standard is adjudged uniform within the limits of $\pm 4 \times 10^{-6}$ in its index of refraction. The optical heterogeneity distribution found within the whole disk is in accord with the hypothesis that the variations are caused mainly by temperature gradients which exist during the annealing or which change during the cooling procedures. R.A.H.

Tests prove permanency of transmitting power of ultra-violet glass. ANON. *Amer. Glass Rev.*, **49** [5], 35 (1929); *Nat. Glass Budget*, **45** [27], 18 (1929).—Exhaustive tests conducted both in England and on an ocean steamer exposed to blazing sub-tropic sunlight have developed new evidence on the permanency of transmitting powers of ultra-violet ray window glass, and have entirely upset previous tests by proving them founded on false hypotheses. The tests were conducted by the Research Laboratory of the Crown Glass Works at St. Helens, England. It was developed that (1) the chemical stabilization process (solarization) of ultra-violet ray window glass takes place in a few days in natural sunlight; (2) there is a definite level at which the transmitting power of

the glass stabilizes and remains fixed; (3) solarization of ultra-violet glass by artificial means causes far more loss in the transmitting power of the glass than could be caused by exposure to natural sunlight. Further, such artificially solarized glass when exposed to sunlight actually regained what it had lost through the excessive exposure to artificial rays. E.P.R.

Data on ultra-violet solar radiation and solarization of window materials. W. W. COBLENTZ AND R. STAIR. Bur. Stand., *Jour. Research*, **3** [5], 629–89 (1929); for abstract see *Ceram. Abs.*, **8** [5], 332 (1929). R.A.H.

Glass as architectonic decoration medium. WILHELM MOUFANG. *Keram. Rundschau*, **37**, 145–46 (1929). H.I.

France builds revolving solarium. ANON. *Nat. Glass Budget*, **45** [25], 13 (1929).—An Associated Press dispatch from France says that a revolving solarium always turned toward the sun is being built here by Jean Saidman, Chief of the Institute of Actinology. Mounted on a 50 ft. tower, a glass-enclosed gallery, 85 ft. long, will provide room for many patients. By revolving the solarium, the sun's rays may be utilized at the angle deemed most beneficial. Should clouds shield the sun, artificial ultra-violet and infra-red rays will be furnished by electrical equipment. E.P.R.

Largest solarium in world contains 1200 fused quartz windows. ANON. *Amer. Glass Rev.*, **49** [3], 32–33 (1929); for abstract see *Ceram. Abs.*, **8** [12], 876 (1929). E.P.R.

Building of the glass industry at the Poznan exposition. ANON. *Amer. Glass Rev.*, **49** [3], 26 (1929); for abstract see *Ceram. Abs.*, **8** [10], 777 (1929). E.P.R.

Glass-walled theater for Berlin. ANON. *Amer. Glass Rev.*, **49** [4], 20 (1929).—Plans for the construction of a big new theater to be built of glass and steel have been submitted to the German Steel Trust, which, it is said, is favorably inclined toward the project. The outer walls of the building will be of steel. There will be an inner wall of glass capable of providing marvelous lighting effects, while between the two walls there will be a narrow space for ventilation purposes. The coulisses will also be made of glass. It is claimed that the acoustics of such a building will be such as to reveal formerly hidden possibilities of the human voice. E.P.R.

Glass house in Gelsenkirchen. ANON. *Diamant*, **51** [1], 3 (1929).—A description of the new building of the firm of Meyer & Hellenthal in Cologne, in which colored opaque glass was used as a major building material the façades being covered with opaque onyx green glass in wide stripes. Illustrated. E.J.V.

Glass as major building material. ERWIN S. CHANIN. *Glass Ind.*, **10** [11], 220 (1929); for abstract see *Ceram. Abs.*, **8** [12], 876 (1929). E.J.V.

Glass competes with marble. ANON. *Glass Ind.*, **10** [11], 274 (1929).—Glass, which is being used more and more in architectural construction, was recently employed in the erection of a mausoleum at Shelbyville, Ind. Sani-Onyx, the material used, is declared to be a more advantageous material for this type of work than marble in that it is non-absorbent and consequently does not hold dampness as does marble. The entire interior of the 400-crypt mausoleum was lined with glass. The product is also being used quite extensively for walls and ceilings in bathrooms, kitchens, and surgeries; for window sills and for wainscoting corridors, lavatories, and toilets of public buildings. Illustrated. E.J.V.

Manufacture of wire glass. V. JOSEPH ROSSMAN. *Glass Ind.*, **10** [11], 266–69 (1929).—Thirty-three patents dealing with the manufacture of wire glass, dated from May, 1910 to April, 1929, are briefly discussed and their chief features are enumerated. A list of 77 U. S. patents granted for machines making wire glass is also included, dating from September, 1892 to January, 1928. For previous abstract see *Ceram. Abs.*, **8** [12], 875 (1929). E.J.V.

Chromium plating of pressed glass molds. ANON. *Ceram. Ind.*, **13** [5], 465

(1929).—It has been said that chromium plating of glass molds provides a far greater life to the molds and thus indirectly cuts down repair costs. The plating operation also tends to make the mold sharper in its outline and helps produce a better product. F.P.H.

Machine producing 80 bottles per minute. ANON. *Ceram. Ind.*, **13** [5], 465–66 (1929); for abstract see *Ceram. Abs.*, **8** [3], 178 (1929). F.P.H.

New design in bottle machine. ANON. *Ceram. Ind.*, **13** [5], 466 (1929); see *Ceram. Abs.*, **8** [12], 876 (1929). F.P.H.

Press and blow machine employs solid blank molds. ANON. *Ceram. Ind.*, **13** [5], 466–67 (1929).—A new press and blow machine is an interesting development in the bottle manufacturing field. This machine, which is known as the Moorshead, is continuous in operation and employs solid blank molds, thus making it possible to use a shouldered parison. Split neck rings are also employed so that any bottle that can be made on any other type of machine can be made on this machine, so long as the ratios between the width of the opening and the weight or proportions of the glass are within the necessary limits. This advantage seems to increase its range over other types of press and blow machines now in use. Being continuous in operation and employing a separate plunger for each head, very high speeds are made possible. For previous patent on this machine see *Ceram. Abs.*, **8** [2], 112 (1929). F.P.H.

Machine blown bottles. E. P. PARTRIDGE. *Ind. Eng. Chem.*, **21** [7], 638–43 (1929).—P. describes the manufacturing of bottles at the Alton, Illinois plant of the Illinois Glass Co. Raw materials are received at the batch plant where they are weighed and mixed in batches, and delivered by cars on an elevated railroad to the furnace hoppers in the main plant. Approximately 125,000 T. of material are passed through the batch plant in the course of a year. The furnaces are of the Siemans regenerative type and are constructed with a bridge wall separating the melting and refining sections. The furnaces are fired with gas from Chapman semi-automatic producers, each producer having an average consumption of 19 T. of coal per day and an average production of 2 million cu. ft. of gas for the same period. The furnace linings have an operating life of from 12 to 15 months of continuous service. When a furnace has been completely rebuilt 21 to 23 days of gradual heating are necessary to bring the new furnace to the normal operating temperature (2500 to 2700°F). P. gives a very complete description of the gob and vacuum feeds for blowing the glass, both of which are used at this plant. The largest bottle-blowing machine in the world is located in the Alton plant. The machine produces an average of 8500 completed 5-gallon carboys per 24 hrs. Both gas and electrically heated leers are used, automatic temperature control allowing a maximum variation of 9°F in any zone. The bottles are taken from the leers to storage, representative samples being taken at periodic intervals and subjected to rigid tests. In addition to a mechanical research department, this company maintains a well-equipped chemical and physical laboratory. P. presents a number of excellent photographs showing stages of manufacture and also discusses some economic considerations in automatic bottle manufacture. R.G.M.

Machine for edging glass sheets. ANON. *Ceram. Ind.*, **13** [5], 466 (1929).—A mechanical traveling frame is provided by which the plate of glass may be automatically sent through the machine at a uniform rate of speed and a uniform pressure is applied throughout the length of the edge of the plate glass. In this way the edge is true and even throughout the entire length. It will not cause safety glass to slip or separate. F.P.H.

Klages automatic glass edger. ANON. *Nat. Glass Budget*, **45** [25], 20 (1929).—This machine is built with two spindles to edge and bevel mirror plates up to 22 in. in length. It bevels 100 in. of glass per min. and with the second spindle edges another

100 in. per min., including handling time. Two unskilled operators are required to put on and take off the glass. One-sixteenth inch depth of cut is removed from 1 to 4 in. thick plate glass in the edging operation, and $^3/_{16}$ in. bevel at 45° in the beveling operation. This machine is built by the G. W. Klages & Son, Inc., Pittsburgh, Pa. E.P.R.

Surface polishing and removal of capillary cracks or flaws. ANON. *Diamant*, **51** [4], 64–65 (1929).—Handling and care of polishing felts are of great importance in surface polishing of glass. Only best quality rouge can be used for polishing glass and removing hair-line cracks from the surface. Theoretical considerations of polishing processes are discussed. E.J.V.

Explosions in production of mirror coatings. WERNER MYLIUS. *Diamant*, **51** [3], 42–44 (1929).—The chemistry of preparing silvering solutions for mirror silvering is discussed and it is pointed out how there is a possibility of such explosive compounds as silver amide ($AgNH_2$) being formed due to the combination of silver and part of the ammonia, or in case other ingredients are used in preparing the solutions, other explosive compounds may be formed. E.J.V.

Prevention of explosions in mirror silvering materials. MAX ERMES. *Diamant*, **51** [4], 62–63 (1929).—In the preparation of a silvering mixture there is a possibility of the formation of a fulminate of silver (CNOAg) on the addition of alcohol to a concentrated solution of silver oxide in ammonia. Two kinds of silver fulminate, Howard's and Berthelot's, are formed and they are both more explosive than the best gunpowders. Precautions to be taken to prevent accidental explosions while preparing and working with silvering solutions in mirror manufacture are discussed. E.J.V.

Copper plate on glass. ANON. *Brass World*, **25** [10], 240 (1929).—Method for copper-plating glass is given. E.P.R.

Mirror production. ARTHUR LAURENT. *Diamant*, **51** [7], 121–22 (1929).—Special discussion of the preparation, by polishing, of defective glass, and of the polishing machine is presented. See also *Ceram. Abs.*, **7** [1], 16; [7], 435 (1928); and **8** [1], 24 (1929). E.J.V.

Simplify bottle sizes. ANON. *Nat. Glass Budget*, **45** [27], 25 (1929).—Large savings are expected to result from the adoption of recommendations which are to be presented by a simplified practice committee at a general conference on the simplification of sizes of bottles used by the carbonated beverage industry. E.P.R.

Second International Exhibition of Industrial Art. CHARLES R. RICHARDS. *Amer. Mag. Art*, **20** [11], 604–14 (1929).—This group collected by the American Federation of Art is limited to glass and rugs. Decorative table glass has undergone a remarkable renaissance in the last forty years and many techniques especially of French work are included in the exhibition. Along with true glass the ancient Roman pâte de verre intermediate between ceramics and glass and permitting delicate effects, has been revived. Another French development is that of small figures worked with a Bunsen flame. Orrefors and Vienna contribute an extraordinary revival of engraved glass. Germans have concentrated upon fine simplicity in aesthetic effects often with a minimum of labor. The French brought forward in lighting fixtures the conception that only two elements are needed, electric bulbs and translucent glass for diffusion. Illus. E.B.H.

Sheet glass production by machine in U.S. A. STANG. *Keram. Rundschau*, **37**, 35–38, 72–73 (1929). H.I.

Position of glass industry in Bavaria and Saxony. BENNO SCHMIDT. *Keram. Rundschau*, **37**, 130–31 (1929).—An analysis of industries in these provinces on the basis of number of persons employed and distribution of employees in large and small plants. H.I.

Mirror manufacture in U.S. ANON. *Nat. Glass Budget*, **45** [25], 16 (1929).—

The government Census of Manufactures gives 250 establishments working on mirror production. E.P.R.

Safety glass to be manufactured in South Africa. SAMUEL H. DAY. *Commerce Repts.*, **42,** 170 (1929); *Nat. Glass Budget*, **45** [26], 16 (1929).—Manufacture of laminated glass for automobile windshields has been announced by the Plate Glass Beveling and Silvering Co., Cape Town, S. Africa. The process used has been obtained under license from a British manufacturer. This type of glass has heretofore been available in S. Africa only as original equipment or by importation cut to size. Importation of this type of glass for replacement purposes will consequently be restricted. E.J.V.

Belgian glass industry. WILLIAM C. BURDETT. *Commerce Repts.*, **46,** 428–29 (1929).—Factories producing glass by the old mouth-blown system are gradually going out of business, and there are at this time only six remaining in Belgium. These, as a rule, produce thin glass and photographic glass. The number of Fourcault machines is increasing and there are about 154 machines now in action in Belgium. (See also *Ceram. Abs.*, **8** [12], 877 (1929).) E.J.V.

Glass manufacture in China. ANON. *Pottery Gaz.*, **54** [629], 1791 (1929).—A project is being worked out for the production of drawn glass in China by a Chinese company with German experts. Harbin or Hankow is to be the site. Both places are suitable as to raw material, labor, and market. It is calculated that with the available capable Chinese labor the glass can be made appreciably cheaper than the imported. E.J.V.

Lower glass production. ANON. *Can. Chem. Met.*, **13** [10], 34 (1929); *Nat. Glass Budget*, **45** [25], 13 (1929).—Latest statistics for production of the glass industry in Canada record last year's output as valued at $13,565,354, a 3% decrease from the record value for 1927. Fifty-nine firms were engaged in the manufacture of glass products. Of the seven plants producing pressed and blown glass, five actually made glass, and two made vials and other special apparatus from tubes, rods, etc. The remaining 52 factories manufactured plate, cut, and ornamental glass. During 1928, glass and glassware at the value of $9,294,095 were imported into Canada, an increase of over a million dollars over 1927. This total included 45.5 million sq. ft. of common window glass; plate and sheet glass, $2,921,210; glass carboys, demijohns, bottles, etc., $1,485,205; glass tableware, $1,041,826. Exports also showed an increase. E.J.V.

Glass industry in Poland. ANON. *Ceram. Verrerie*, **49,** 29 (1929).—The window-glass industry in Poland is passing through a crisis due to insufficient tariff protection. Czechoslovakian glass is unloaded on the Polish market and sold for 1.85 zlotys per sq. meter, while the price in Czechoslovakia is 4.82 zlotys. A.J.M.

Simplified costs for glass plant operations. D. D. LILLEY. *Ceram. Ind.*, **13** [5], 487–89 (1929).—Various functions of a cost system are discussed. F.P.H.

Cellulose container may compete with that of glass. ANON. *Nat. Glass Budget*, **45** [26], 3 (1929).—A new container said to have nearly the strength of metal and almost as transparent as glass and of less weight than either, is reported to be a recent development. E.P.R.

Production of artificial glass materials. T. J. K. *Diamant*, **51** [6], 104–105 (1929).—Some recipes for producing artificial "glass" from such substances as urea, formaldehyde, phenol, calcium cyanamide, and hydrochloric acid are presented and the various products discussed. E.J.V.

Synthetic precious stones. ESPIG. *Diamant*, **51** [7], 124–25; [8], 143–44 (1929).—Production of artificial precious stones of colored glasses, method, and coloring oxides used therefor, and properties required in synthetic jewels are discussed. E.J.V.

Theory of glass drawing and blowing. HEINZ SCHLECHTWEG. *Ann. Physik*, **5** [2], 805–46 (1929).—A mathematical paper. (*C.A.*)

Analysis of the gases emitted by glass. S. KONDRASHEVA. *Jour. Applied Phys.* [Moscow], **5**, 23–38 (1928); *Physik. Ber.*, **9**, 2012 (1928) (in Russian with English summary).—A method is described for the determination of the gases given off by glass below its melting point under 10^{-4} mm. pressure. Three kinds of glasses have been tested. Below the softening point, gases are given off which are vigorously absorbed by alkaline oxides. Above the softening point, H and CO are liberated; they were probably dissolved in the glass. (*C.A.*)

Investigation of glass by Margule's method. M. VOLAROVICH. *Jour. Applied Phys.* [Moscow], **5**, 185–91 (1928); *Physik. Ber.*, **9**, 2008 (1928) (in Russian with English summary).—The viscosity of a glass sample has been measured by the Margule's method; the molten glass has been located in the clearance between a motionless Pt Ir cylinder and a concentric inside cylinder revolved regularly by the fall of a weight. The ranges were temperature 970 to 1390°, viscosities 176 to 21,700 absolute units. The viscosities could be calculated satisfactorily by the Le Chatelier equation. (See following abstract.) (*C.A.*)

Investigation of viscosity of glass by Stoke's method. B. V. DERYAGIN AND I. M. KHANANOV. *Jour. Applied Phys.* [Moscow], **5**, 193–99 (1928); *Physik. Ber.*, **9**, 2008 (1928) (in Russian with English summary).—The viscosity of a glass sample has been determined at various temperatures by the Stoke's method (falling Pt Ir ball). The results agree satisfactorily with those reported in the preceding abstract. (*C.A.*)

Fused quartz as construction material in chemical industry. Z. VON HIRSCHBERG. *Korrosion*, **4**, 25 (1929).—A table gives the resistance of quartz to NH_4OH, NaOH, KOH, Na_2CO_3, $Ba(OH)_2$, and Na_2HPO_4. (*C.A.*)

PATENTS

Glass mold. ALBERT J. THROM. U. S. 1,736,637, Nov. 19, 1929. A mold of the kind specified having an article-forming cavity, a base member on which the mold is mounted, a plunger movable in the base member, a pump carried by the base member and in communication with the cavity, the pump having a piston for the extraction of air from the cavity and for the actuation of the plunger.

Manufacture of glass cylinders. CHARLES H. HARDING. U. S. 1,736,005, Nov. 19, 1929. Method of manufacture of glass cylinders which comprises drawing the cylinder upwardly from a body of molten glass in a pot, and turning the pot on its axis while restraining the body of the cylinder from turning.

Pot and kiln construction. WILLIAM WESTBURY AND PATRICK W. COLLINS. U. S. 1,736,026, Nov. 19, 1929. In a glass-drawing apparatus, the combination with a kiln having an eye inclined from the horizontal, of a pot carrier having a pair of pots lying at an angle to each other such that one may be in drawing position and the other in the kiln eye, means for shifting the pot carrier to bring the pots alternately to drawing position and to draining position relative to the kiln eye, and means for relatively shifting the draining pot and kiln eye without destroying drawing position of the drawing pot.

Annealing glassware. VERGIL MULHOLLAND. U. S. 1,736,322, Nov. 19, 1929. A leer for annealing glassware comprising a tunnel, a fire box arranged adjacent to the entrance end of the tunnel, a plurality of flues communicating with the fire box and extending longitudinally of the tunnel and having openings for establishing communication therebetween at intervals longitudinally thereof to equalize the draft therein.

Controllably feeding gases. JASPER M. ROWLAND. U. S. 1,736,509, Nov. 19, 1929. Method for obtaining a supply of a fluid, in gaseous phase, from a source of supply of the fluid in liquid phase, by the operations of withdrawing the fluid in liquid phase from the source of supply, and vaporizing the same, which comprises maintaining equilibrium pressure conditions throughout the operations.

Treating glass for illumination purposes. SHERMAN G. NYE. U. S. 1,736,619, Nov. 19, 1929. A lens for lamps comprising a sheet of glass having one face thereof plain and the other face roughened, a coating of transparent oil on the other face, and a coating of transparent material superposed on the oil coating.

Sheet-glass forming apparatus. JAMES C. BLAIR. U. S. 1,735,595, Nov. 12, 1929. In sheet-glass apparatus, a receptacle containing a mass of molten glass, the receptacle having an adjustable end adapted to form an orifice beneath the glass level of the glass therein, whereby a stream of glass flows from the receptacle under head pressure, means for adjusting the adjustable end to vary the size of the orifice, and means for reducing the stream to sheet form.

Surfacing plate glass. JOSEPH P. CROWLEY. U. S. 1,735,599, Nov. 12, 1929. In an apparatus for surfacing sheet glass, a sheet-supporting table rotatable about a vertical axis, a surfacing element resting freely on the upper face of the sheet, means for rotating the table, means for raising and lowering the surfacing element to and from contact with the sheet, and automatic control mechanism for lowering the surfacing element into engagement with the sheet, starting the rotation of the table, and after a predetermined time elevating the surfacing element and stopping the table.

Abrasive-feeding system for glass-grinding machines. JOSEPH P. CROWLEY. U. S. 1,735,600, Nov. 12, 1929. In a system for supplying abrasive to a plurality of grinding machines, means for maintaining a circulation of the abrasive past the several machines, means at each machine permitting withdrawal of a portion of the abrasive when desired, a series of storage reservoirs for different grades of abrasive, means permitting selective replenishment of the circulating system from these reservoirs, and a series of grading tanks for supplying the reservoirs.

Feeding molten glass. KARL E. PEILER. U. S. 1,735,837, Nov. 12, 1929. (1) Apparatus for feeding molten glass, comprising a container having a discharge outlet, a rotary implement projecting into the glass in the container, a rotatable support for the implement, a bearing carrying the support, a housing adjacent to the bearing, and means for projecting cooling air into the housing. (2) Apparatus for feeding molten glass, comprising a container having a discharge outlet, a rotary implement extending into the glass in the container, and mechanism for supporting and rotating the implement, comprising a rotatable annular support, a bearing therefor, and a holder for the implement comprising clamp members carried by the rotatable support, one of the clamp members being removable from the support to enable the implement to be removed upwardly from the holder through the annular support.

Glass-delivering apparatus. DAVID STENHOUSE. U. S. 1,735,551, Nov. 12, 1929. (1) An apparatus for delivering glass, including a flow spout having a flow orifice, a reciprocable plunger in vertical alignment with the flow orifice, a piston and piston rod for operating the plunger and arranged in vertical alignment therewith, a rotary rod carried by the piston rod, the plunger attached to the rotary rod, a worm wheel keyed to the rotary rod and having sliding movement thereon, a worm engaging the worm wheel and an electric motor for operating the worm. (2) An apparatus for delivering glass, including a reciprocable plunger and means for mounting the plunger, the means comprising a socket member, the socket member and plunger having registering apertures, a pin adapted to be inserted in the registering apertures, and a movable clamp adapted to engage the opposite side of the plunger. (3) An apparatus for delivering glass including a reciprocable plunger, two elements for limiting the up-and-down stroke of the plunger, an adjustable connection between the two elements, and a screw-threaded rod engaging one of the element for simultaneously adjusting the two elements.

Sheet-glass surfacing apparatus. JOHN L. DRAKE. U. S. 1,735,565, Nov. 12, 1929. In a machine for surfacing sheets of glass, a plurality of traveling surfacing tools, a work

table carrying the sheets to be surfaced, and movable so that the same parts of the same piece of work are presented successively to different tools, a stationary source of supply of abradant at a fixed point in the course of travel of the work, and a fixed means adjacent such point of supply and in the path of travel of the tools for raising each tool as it is brought by its travel to such fixed means, permitting the abradant to enter between the tool and work, and when the tool passes such means permitting the tool to again descend and treat the work with the abradant.

Drawing continuous sheet glass. JOHN C. HENDERSON. U. S. 1,735,573, Nov. 12, 1929. (1) That improvement in drawing sheet glass, which consists in supporting a portion of the moving sheet while being bent from one plane into another upon a blanket of air which is mechanically moved with the sheet. (2) In a sheet glass drawing apparatus, means for supporting the glass sheet while it is being bent from one plane to another, including a rotatable fan member mounted within the bending arc of the sheet operated in a manner to create an air cushion for supporting the main body part of the sheet, the air cushion moving in the direction of travel of the sheet.

Glass-severing mechanism. EVERETT O. HILLER. U. S. 1,732,305, Oct. 22, 1929. In combination with a glass-feeding device, pneumatically operated shears coöperating therewith, a valve for controlling the admission of fluid pressure to the shear mechanism, mechanical means for interrupting the movement of the shears, and cam-operated means for actuating the valve and for controlling the movement of the interrupter to regulate the closing of the shears.

Glass-polishing apparatus. ARCHIE W. PLATT. U. S. 1,732,695, Oct. 22, 1929. In a machine of the class described, a conveyer for supporting plate glass and having a defined path of movement, a polishing unit having two defined paths of movement across the conveyer transverse to the conveyer movement, means for transferring the unit from one path of transverse movement to the other, separate means for feeding the unit from one side to the other of the conveyer in the path of movement in which disposed, means for rotating the unit during its movements across the conveyer, and means forming a part of the transferring means for conditioning the working surface of the unit at an end of each path of movement while the unit is rotating.

Apparatus for obtaining charges of molten glass. KARL E. PEILER. U. S. 1,732,771, Oct. 22, 1929. Apparatus for separating molten glass into mold charges of different weights, comprising a container having a discharge outlet, mechanism for periodically extruding glass through the outlet, severing mechanism below the outlet, and means for operating the severing mechanism at the end of intervals of different duration in a given cycle.

Method of and apparatus for feeding molten glass. DANIEL A. RIPLEY. U. S. 1,732,773, Oct. 22, 1929. In a machine for feeding molten glass, the combination with a container adapted to contain a pool of molten glass, means for continuously supplying glass thereto, and a displacement member adapted to coöperate with the container to expel successive quantities of glass therefrom, of means for operating the parts in successive strokes and for varying in predetermined order the amplitude of successive strokes for the successive expulsion from the container of different predetermined quantities of glass.

Manufacture of glass. CHARLES HEUZE. U. S. 1,732,889, Oct. 22, 1929. In an apparatus for forming and annealing glass sheets the combination with an intermittent forming machine, of a tiltable runway located adjacent to the forming machine and adapted to receive sheets therefrom when inclined, a leer, and means for varying the inclination of the runway and placing it in a substantially horizontal position in alignment with the leer.

Polishing plate glass. JOSEPH P. CROWLEY. U. S. 1,733,295, Oct. 29, 1929.

In an apparatus for polishing plate glass, in combination, a series of polishing tools, and a table having a recess providing a flat sheet-supporting surface, with surrounding tool-supporting surfaces.

Glass-forming machine. LEONARD D. SOUBIER. U. S. 1,733,473, Oct. 29, 1929. Glass-forming apparatus comprising, in combination, a continuously rotating mold carriage, circumferentially spaced arms extending radially from the carriage, a neck mold movable radially of the carriage intermediate the arms, a blank mold normally positioned at the outer end of the path of travel of the neck mold, a slide connection between the blank mold and one of the afore-mentioned arms, means periodically moving the slide and blank mold transversely with respect to the arm, additional means for raising and lowering the blank mold into and out of engagement with the neck mold, a partible finish mold arranged inwardly from the blank mold, means effecting operative engagement between the finish mold and neck mold in timed relation with movement of the blank mold, and pneumatic ware-blowing means associated with the molds, the pneumatic means including a blow head movable with the neck mold radially of the mold carriage.

Apparatus for handling glassware. EDWARD H. LORENZ. U. S. 1,733,547, Oct. 29, 1929. Take-out apparatus for removing glassware from molds, comprising ware-gripping tongs, means for imparting traveling movement to the tongs in a horizontal direction, mechanical means for raising and lowering the tongs at each end of their path of travel, and means controlled by the raising and lowering means, for closing the tongs when in their lower position at one end of the path of movement, and for opening the tongs when in their lowermost position at the other end of the path of movement.

Grinding, smoothing, and polishing apparatus. SÉRAPHIN WEROTTE. U. S. 1,734,065, Nov. 5, 1929. In an apparatus for grinding, smoothing, and polishing plate glass, sheet glass, and other materials, including members always performing the same work, the combination of movable tables arranged one after the other, means for moving the tables in a continuous manner beneath the members, the tables being grouped in two rows, arranged one near the other so that the end of one row is near the beginning of the other, and means for transporting the tables leaving one row to the entrance of the neighboring row; the transporting means including a transfer frame and a device which delivers to the frame the table leaving one row of tables, at a higher speed than that of the row.

Producing sheet glass. NICKLAS FRANZEN. U. S. 1,734,250, Nov. 5, 1929. In combination with a glass-melting furnace, means for forming sheet glass comprising forming rolls, and sheet-severing means comprising coöperative sets of cyclically successively engaging shearing members, and sheet-propelling means comprising driven rolls with refractory sheet-supporting members intermediate them.

Manufacturing continuous glassware. EDWARD DANNER. U. S. 1,734,964, Nov. 12, 1929. Forming continuous glassware which consists in flowing molten glass in more than two thin streams along a plurality of directing members in the presence of a heated atmosphere, uniting the streams while still molten, into a single sheet, and taking the sheet away as rapidly as formed and permitting it to cool, the inner surfaces only of the outer streams having contact with the directing members.

Forming glassware. EDWARD DANNER. U. S. 1,734,965, Nov. 12, 1929. (1) Forming continuous glassware, which consists in freely flowing more than two streams, from at least two separate sources of molten glass, through a heated atmosphere and uniting the streams into a single stream before leaving such atmosphere. (2) In apparatus for forming sheet glass, separate receptacles for molten glass, there being slots in the receptacles from which films of molten glass issue, and means in position to contact inner surfaces of films thus issuing and guide and control the movement of the glass, the means

extending below any members contacting the exterior surfaces of the exterior films and the guiding means for different films being at different angles, the guiding surfaces of the means being of different lengths for different films.

Producing double-walled glass containers. MINER P. WETMORE. U. S. 1,735,027, Nov. 12, 1929. In apparatus for producing double-walled glass containers, the combination of a vertical rod adapted to support an inner cylinder in inverted position, means carried by the rod to engage the lower end or neck of the cylinder and thereby hold the latter against side movement, a chuck arranged to hold an inverted outer cylinder concentrically over the inner cylinder, means for simultaneously rotating the rod and chuck at the same speed, whereby the inner and outer cylinders rotate as a unit about their common vertical axis, and means for applying heat to the outer cylinder until the same is fused to the lower end of the inner cylinder, the two cylinders being rotated during the fusing operation so as to form a sealed annular joint at the neck.

Annealing glassware. VERGIL MULHOLLAND. U. S. 1,735,353, Nov. 12, 1929. A leer comprising side and bottom wall members and a top wall member forming a tunnel, at least one of the members being divided longitudinally of the tunnel into a plurality of portions, means for moving the ware through the tunnel, a plurality of stacks arranged at intervals longitudinally of the tunnel, each associated with one of the portions for controlling the temperatures in the tunnel, longitudinally thereof, and means to permit independent adjustment of the portions to vary the cross-sectional areas of the tunnel throughout selected zones, whereby to selectively control the amount of gases passing out the several stacks and consequently to selectively control the rate of cooling of the ware throughout selected portions of the tunnel.

Framework for glass-polishing units, etc. ARCHIE W. PLATT. U. S. 1,735,410, Nov. 12, 1929. Framework for supporting a multiplicity of glass polishing units, etc., composed of a series of horizontally disposed V-shaped members arranged with the open ends of the members in juxtaposition to the like ends of the adjacent members to provide a zigzag assemblage, supporting means for the glass-polishing units extending transversely across the spaces between and connected to the adjacent apex portions of adjacent members, means to connect the units to the supporting means in depending relation to the supporting means so as to support the units in the spaces between the adjacent apex portions of adjacent members, a polishing bed disposed beneath the units for supporting the glass to be polished and means to operate the units.

Glass blowing. BULLMAN MACHINE CO., LTD. Brit. 318,134, Oct. 23, 1929. Relates to rotary glass-blowing machines of the kind in which each parison mold consists of two parts carried by arms adapted to swing laterally about a vertical hinge pin. According to the invention, the arms carrying a parison mold are disposed centrally between two vertical guide bars which are disposed one behind the other in a direction radial to the vertical axis of the machine. The mold is opened by a cam and closed by a spring, and the movement of the cam is transmitted to the mold by means of a vertical rotatable shaft which influences the spring. Auxiliary closing devices are provided for exerting a closing-pressure on the halves of the mold, and the arms are used for conveying air for cooling the mold.

Glass blowing. BULLMAN MACHINE CO., LTD. Brit. 318,135, Oct. 23, 1929. Relates to a rotary glass-blowing machine of the kind in which a number of mold units rotate about a vertical axis and in which the finishing molds may be of different heights and are disposed on vertically adjustable tables. According to the invention, the molds are opened by a cam and closed by springs, and the movements produced by the cams are transmitted to the molds by vertical rotary shafts which allow the molds to be moved vertically without necessitating movement of the levers which coöperate with the cam.

Glass blowing. BULLMAN MACHINE CO., LTD. Brit. 318,136, Oct. 23, 1929.

Relates to a rotary glass-blowing machine of the kind in which a number of mold units rotate about a vertical axis. According to the invention, the machine is provided with locking-devices which enable any desired member of a mold unit to be put into and out of operation when desired, even while the machine is rotating.

Glass furnaces. A. SCHILD. Brit. 318,047, Oct. 16, 1929. Relates to a container which is fed continuously with molten glass from a tank furnace and is periodically tilted about a longitudinal axis in order to pour the glass onto a machine for making plate glass. According to the invention, the pouring-lip of the container is normally above the level of the glass in the tank while glass is flowing into the container, so that the flow stops automatically when the glass in the container is at the same level as that in the tank.

Delivering molten glass. H. WADE. Brit. 318,063, Oct. 16, 1929. A feeder of the reciprocating-plunger type has a cutting-device which comprises reciprocating shear blades, and the mechanism for reciprocating the blades comprises a driving-link which also closes the shears at a predetermined position relative to the outlet. The feeder is constructed as described in Brit. 316,837. See *Ceram. Abs.*, **8** [12], 880 (1929).

Forming glass threads. L. MATHIEU. Brit. 318,078, Oct. 23, 1929. Relates to the manufacture of glass threads and consists in drawing the glass directly from a tank furnace. The side walls of the tank are formed with one or more ports or apertures into which perforated plates are fitted. The glass flows through the perforations in the plate and forms threads which are wound onto the surface of a drum in the usual manner.

Forming glass tubes. P. A. FAVRE. Brit. 319,361, Nov. 13, 1929. Relates to the method of making glass tubing, described in Brit. 300,646(see *Ceram. Abs.*, **8** [4], 266 (1929)) and Brit. 304,664 (see *Ceram. Abs.*, **8** [6], 410 (1929)), in which one or more cylindrical glass blanks are threaded on a tubular mandrel having a conical extension at its lower end to support the blanks. The lowest blank is heated by gas flames, and the glass as it melts runs over the enlargement and is drawn off by a suitable drawing device. The present invention consists mainly of modifications of the apparatus described in the prior specifications.

Glass blowing. BULLMAN MACHINE CO., LTD. Brit. 318,137, Oct. 23, 1929. Relates to a rotary glass-blowing machine of the kind in which a number of mold units are carried by a frame that rotates about a vertical column. According to the invention each mold unit comprises a carrier which is movable vertically between a pair of guide bars, and the bars of each pair are disposed one behind the other in a direction radial to the vertical axis of the machine. By this construction, the peripheral dimensions of the machine are reduced to a minimum.

Glass blowing. BULLMAN MACHINE CO., LTD. Brit. 318,138, Oct. 23, 1929. Relates to a rotary glass-blowing machine of the kind which comprises a number of mold units carried by arms that radiate from a central vertical column. According to the invention, the cams that control the various working-operations of the units are divided into two groups, one of which is fixed to the machine base while the other is arranged on a segment so mounted as to be movable relatively to the first group.

Glass blowing. BULLMAN MACHINE CO., LTD. Brit. 318,139, Oct. 23, 1929. Relates to a rotary glass-blowing machine of the kind which comprises a number of mold units carried by arms that radiate from a central vertical column. According to the invention, the central column is dispensed with and the cams that control the working-operations of the units are disposed below the level of the units where they impose no hindrance to the constructional design of the machine parts.

Glass blowing. BULLMAN MACHINE CO., LTD. Brit. 318,140, Oct. 23, 1929. Relates to a rotary glass-blowing machine of the kind which comprises a number of mold units carried by arms that radiate from a central vertical column. According to the invention, the central column is dispensed with and the units are mounted on a rotating

annular member. The cams that control the working-operations of the units are disposed below the level of the units so as to leave a central space, unhampered by any column, to which access can be obtained from below the base of the machine.

Gathering molten glass. C. H. RANKIN AND RANKIN AUTOMATIC GLASS FEEDER CO., LTD. Brit. 319,178, Nov. 6, 1929. Relates to a forehearth or trough from which charges of glass are gathered by the molds of a suction-gathering machine. The invention consists in using a rotary member, dipping into or immersed in the glass, to circulate the glass through the forehearth in order to ensure that a supply of clean, unchilled glass is constantly maintained at the gathering point.

Glass rolling. A. E. WHITE. Brit. 319,182, Nov. 6, 1929. Relates to apparatus for making plate glass in which a body of glass is poured into the pocket between parallel rollers and is prevented from spreading sideways by means of metal plates which fit into the pocket between the rollers. The invention consists in causing the glass to adhere to these end plates as it is found that such adhesion causes the rolled plates or strips to have smoother edges.

Glass manufacture. CORNING GLASS WORKS. Brit. 319,337, Nov. 13, 1929. Relates to the production of glasses which transmit a high proportion of ultra-violet rays by using batch materials which are free from iron and titanium. The present invention deals with the selection and treatment of the batch materials. The silica preferably consists of vein quartz which has been crushed and then treated to remove any iron introduced during crushing. In making a borosilicate glass, a boron compound is added to the batch in such a quantity that, in the resulting glass, the sum of the percentages of silica and boric oxide is from 10 to 22 times the sum of the percentages of alkalis, and the percentage of silica is at least five times that of the boric oxide. When iron is present, a reducing material is necessary and carbon, or a carbonaceous compound, is convenient for this purpose. Carbon imparts a yellow or amber color to the glass, but the addition of zinc oxide neutralizes the yellow color and the resulting glass has a bluish green tinge. The zinc oxide should be specially purified to remove any traces of lead that may be present. The batch is melted in pots made of fused quartz, or in small tanks constructed of good quality silica brick. The air and fuel gases used for heating the furnace are preferably filtered, and burners with nickel tips are used to prevent the introduction of iron scale.

Compound transparent sheets. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Brit. 317,369, Oct. 9, 1929. A synthetic resin such as that obtained from formaldehyde and phenol, urea, and formaldehyde, or glycerine, and phthalic anhydride, preferably partially polymerized and dissolved in a suitable solvent, is used for uniting two sheets of glass to a sheet of celluloid, etc., to form a compound transparent sheet. The coated glass sheets and the celluloid sheet are united by pressure in a suitable solvent such as alcohol, acetone, etc., luting of the edges of the compound sheet being unnecessary.

Glass rolling. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Brit. 317,820, Oct. 16, 1929. Producing plate glass in a continuous strip consists in making the glass in a pot furnace, pouring the contents of each pot successively into a heated container which maintains the glass therein at the proper temperature for rolling, and in flowing the glass continuously from the container into a rolling machine, each pot being poured into the container before the whole contents of the preceding pot has flowed into the rolling machine.

Delivering molten glass. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Brit. 317,860, Oct. 16, 1929. Relates to the method of tilting a pot of glass about a horizontal axis situated near its rim in order that the

contained glass may be deposited on the table of a rolling apparatus in a compact mass without laps or folds.

Glass rolling. A. E. WHITE. Brit. 318,430, Oct. 30, 1929. Method of making plate or sheet glass consists in flowing molten glass from a tank furnace in two streams each of substantially the width of the finished sheet, passing one of the streams through the pass between a pair of rollers to form a sheet, applying the second stream of glass to one surface of the sheet while keeping the other surface intact, and then passing the sheet and the applied glass through a second pass to form a sheet of the required thickness. Wire glass may be made by feeding a web of wire onto the sheet first formed before the second stream is applied to its surface.

Compound transparent sheets. SOC. D'ÉTUDE DES VERRES ET GLACES DE SÛRETÉ. Brit. 318,529, Oct. 30, 1929. Compound transparencies composed of sheets of glass and strengthening material are united by suitable adhesive and one or more groups of pressure rolls either while the sheets are immersed in a bath of alcohol or not and by subsequent pressure between heated platens. The pressure rolls are heated when the sheets are pressed out of the bath of alcohol.

Delivering molten glass. BRITISH HARTFORD-FAIRMONT SYNDICATE, LTD. AND T. WARDLEY. Brit. 318,852, Nov. 6, 1929. A skimmer block for the forehearth of a glass-melting furnace or for other apparatus containing molten glass is slidably mounted in guides of nickel chromium alloy or other metal that prevents fusing of the skimmer block to the refractory material forming the sides of the forehearth, etc. A widened upper part of the skimmer block fits in the guides, the lower part being of slightly less width than the passage in the forehearth. Front and rear slabs in conjunction with the guides and an upper slab form a closed or sealed chamber in which the skimmer block is vertically movable. Rods of nickel chromium alloy having hook-like lower ends that extend under the wider part of the block, pass through glands at the upper parts of the guides and are connected to a transverse bar to which may be attached a cable passing over a pulley for adjusting the block. By altering the depth to which the block projects into the molten glass the temperature of the glass may be varied. The block may be raised to provide a through passage for the gases from the furnace to the stack. Openings adapted to receive burners, and ports controlled by plates are provided in the forehearth. For previous article see *Ceram. Abs.*, **7** [4], 229 (1928).

Opaquing agents. DEUTSCHE GASGLÜHLICHT-AUER-G.M.B.H. Fr. 659,518, Aug. 24, 1928. Opaquing agents are made by melting together Zr silicate and about the equivalent amount of CaO, SrO, BaO, MgO, or ZnO with the addition of a flux to produce finely divided combinations of Zr silicate and the oxides. (*C.A.*)

Manufacture of glass. LUDWIG HOCHSTEIN. Ger. 480,753, March 19, 1925. A glass is made by melting together SiO_2, B_2O_3, Al_2O_3, and ZrO_2 in such amounts that the finished glass contains them in the proportions 80 to 85, 16 to 12, 2 to 1.5, and 2 to 1.5%, respectively, with no alkali. (*C.A.*)

Heavy Clay Products

Scum and efflorescence. L. A. PALMER. *Clay-Worker*, **92** [4], 277–78 (1929).—In answer to Ellis Lovejoy's discussion (see *Ceram. Abs.*, **8** [12], 881 (1929)) P. explains some of the terms used in his former paper on this subject. Fixed scum may form on the surface of a clay containing 0.01% of soluble sulphates, mostly alkali sulphates. This scum cannot be washed off by water. In composition, it is essentially a mixture of sodium and potassium sulphates (80% and 20% of calcium sulphate). Petrographic analysis shows that this mixture has none of the optical properties of any of the three salts present, although this would be the case were the material indeed a mixture. It therefore has all the characteristics of what is called a eutectic. It is an unusual occur-

rence on fired-clay bodies and was defined as fixed scum for no other reason than the difficulty involved in removing it. Some facts pertaining to the mechanism of its formation are as follows: (1) it cannot be formed upon clays which do not contain soluble alkali sulphates as well as calcium sulphate; (2) it is not necessary to have any of the gaseous combustion products of sulphur present either in the drier or kiln in order to produce it. In this respect it may also be differentiated from the more common type of scum; (3) it is hard, compact, and opaque, difficultly soluble and cannot be decomposed under any ordinary firing conditions; (4) slow drying tends to increase it whereas rapid drying tends to prevent its formation; (5) addition of barium compounds in sufficient quantity eliminates it entirely, again differentiating it from scum that is formed (both during drying and firing) by the combined action of water and sulphur trioxide upon "bases" such as calcium carbonate, siderite, etc., in the clay; and (6) "fixation" of this salt material occurs at approximately 1600°F. Attention is called to the fact that barium compounds are not recommended as a preventive of kiln scum, but certain precautions observed during drying and firing are far more effective. The addition of barium carbonate to mortar is also discussed, as are "rates" in connection with the drying process and the deposition of alkali sulphates on the surface of clay bodies. E.J.V.

Producing black and green brick. GORDON H. CHAMBERS. *Brick Clay Rec.*, **75** [9], 562–64 (1929).—Practically all stiff-mud red brick manufacturers are making black-flashed brick at the present time. Some brick manufacturers still use the old-fashioned salt and coal flash. The best blue-black headers and stretchers are produced by flashing with some form of manganese. It has been found that the more finely the manganese is powdered, the farther it will travel in the kiln and permeate every recess. It is not vaporized like zinc and for this reason must be finely ground and air-floated. During the flash of a kiln with manganese it must be at a temperature of at least 1850°F as manganese does not fuse or volatilize sufficiently at temperatures lower than this to give good results. If the clay will not withstand this heat it is necessary to use a compound such as Black Flash, which does not give quite as pronounced a blue-black as Air-Floated Ebony Manganese, but is easier to flash readily due to its lower fusing point, or manganese chloride, which has an even lower fusing point. Metallic zinc, up to the present time, is the only material successfully employed for green flashing. The zinc is used in several forms, such as Zinc Flash, a granulated form of metallic zinc mixed with a small quantity of zinc dust. The method of flashing is discussed in some detail.

E.J.V.

Salt glazing stoneware. DIMITREFF. *Keram. Rundschau*, **36**, 558–59 (1928).—In order to demonstrate that the atmosphere of kilns firing stoneware contain large quantities of HCl vapor immediately after salt glazing, D. built an absorbing channel containing water and an absorbing tower containing lump coke between the gas conduit from the kiln and the stack. Since the absorbing channel containing water was close to the kiln, its temperature was too high to permit much absorption of HCl. The coke in the tower (over which H_2O was allowed to drip) had a lower temperature and absorbed much HCl vapor. H.I.

New clay product. EDWARD C. KERTH. *Brick Clay Rec.*, **75** [10], 618–20 (1929).—First of a series of articles dealing with a new ceramic product, the result of an extended research on the development of a new clay process. A new clay material in which porosity and density are controlled with a great degree of exactitude, light in weight, having a high compressive strength, tensile properties, superior insulation, and a fire resistance that exceeds any known building material, has been produced. It is adaptable to cutting, carving, sawing, drilling, or working upon a lathe, and will have a wide application of uses for exterior and interior with a full range of colors and every conceivable texture.

E.J.V.

Compressive strength of clay brick walls. A. H. STANG, D. E. PARSONS AND J. W. MCBURNEY. Bur. Stand., *Jour. Research*, **3** [4], 507–71 (1929).—Compressive tests of 168 walls of common brick, each 6 ft. long and about 9 ft. high and of 129 wallettes, about 18 in. long and 34 in. high were made. Four kinds of brick, 3 mortar mixtures, 2 grades of workmanship, different curing conditions, and 10 different types of masonry (3 solid and 7 hollow) were the variables. Wall strengths were more closely related to the shearing strength of the single brick than to any other strength property of the brick. On an average, the compressive strength of the wallettes was by far a better measure of the strength of the walls than any of the brick-strength values. The use of cement mortar gave higher wall strengths than of cement-lime mortar and much higher than if lime mortar was used. For the solid walls the strength varied about as the cube root of the compressive strength of the mortar cylinders, 2-in. diameter and 4-in. length, cured on the walls. Large differences in strength due to differences in workmanship were found. The walls having smoothed-off spread-mortar beds and filled joints were much stronger than walls in which the horizontal mortar beds were furrowed by the mason's trowel. Some of this difference in strength might be ascribed to difference in the filling of the vertical joints. Some of the walls laid in cement mortar were kept damp for 7 days after construction. These walls were not stronger than similar walls cured under ordinary conditions in the laboratory. The solid walls were stronger than the hollow types. With brick of rectangular cross-section the hollow wall strengths varied about as the net areas in compression. When the brick were not truly rectangular in section, the strength of the hollow walls was found to be less than that expected from the net area. Construction data are given which show the relative saving in materials and time for the hollow types. The results of the wallette tests confirm the conclusions deduced from the wall tests. R.A.H.

Research as applied to bricklaying. ANON. *Can. Chem. Met.*, **13** [10], 22 (1929); for abstract see *Ceram. Abs.*, **8** [12], 882 (1929). E.J.V.

Larger brick for masonry. ANON. *Brick Clay Rec.*, **75** [9], 548–49 (1929).—At a meeting of representatives of various building products and the Division of Simplified Practice on Oct. 8, 1929, at Washington, there was held a discussion of standards for masonry opening, a subject of great importance to the clay products field. At this meeting a larger sized brick was suggested as a means to arrive at a standard, as the brick is considered the key unit in a wall. E.J.V.

German standards for drain tile. ANON. *Tonind.-Ztg.*, **53** [49], 874–75 (1929).—German Industrial Standards (DIN 1180) covering specifications and tests for drain tile are given. F.P.H.

Hollow tile. ANON. *Tonind.-Ztg.*, **53** [51], 907–81; [57], 1020–21 (1929).—A review is given of the German patent literature pertaining to a type of hollow tile that is closed on all sides. F.P.H.

Wear of brick pavement. P. L. BROCKWAY. *Eng. News Rec.*, **101** [8], 286 (1928).—This article gives supporting evidence of the considerable abrasive wear of brick pavements under modern rubber-tired vehicle traffic. Traffic of 3,000,000 T. per ft. of width reduced the thickness of the brick 1 in. Results indicate the necessity of extra thickness of brick on highways subject to heavy traffic. W.L.

Fillers for brick pavements. R. S. BEIGHTLER. *Clay-Worker*, **92** [4], 273–76 (1929).—The question of filler for brick pavements is one which has been given considerable attention in the past few years. The filler is probably of more vital importance since the advent of the $2^1/_2$ in. brick for the $2^1/_2$ in. of filler must accomplish as much or even more than $3^1/_2$ or 4 in. formerly did. An ideal filler must accomplish the following results: (1) seal the joints against water; (2) support the edges and corners of the brick; (3) allow for expansion and contraction; (4) completely fill the joints; and (5)

be comparatively cheap, easily applied, durable, and must leave the surface of the pavement in good condition. Two general classes of fillers, each of which in part meets modern conditions, are cement grout and bituminous material. Descriptions of tests made using nine different bituminous fillers are given. The method of application of the filler is taken up in detail. Recommendations submitted include: (1) use of lug or grooved brick; (2) when grout filler is used it should be designed with expansion joints at intervals of 50 ft. and along the curb; and (3) use of squeegee buckets in applying asphalt filler and the joints to be filled in one application with hot asphalt to within $^1/_2$ in. of the top. This operation is followed by filling the remaining space with sand and final application of asphalt cut back. E.J.V.

Survey of brick pavement performance. WM. H. CONNELL. *Eng. News Rec.*, **101** [18], 652 (1928).—From a survey of performance of a number of brick pavements the following recommendations are made: (1) Vitrified brick for use in pavements should be thoroughly annealed, tough, durable, non-absorptive, and uniformly fired. (2) The stability of a pavement depends on the foundation. The generally accepted foundation is concrete and this will vary in thickness as well as in the mix used under the different traffic, climatic, and subsoil conditions. (3) The type of curb must meet the requirements of each particular job. (4) A sand or granulated slag cushion $^3/_4$ to 1 in. in depth has proved to be the most desirable bedding course. (5) It is essential that brick should be laid in a manner which will definitely provide sufficient space between them for the application of the filler. (6) An asphalt filler has proved to be the most satisfactory and is recommended for general use. W.L.

Practical utilization of building materials for municipal water works. SWYTER. *Tonind.-Ztg.*, **53** [51], 908–910 (1929). F.P.H.

Building brick-faced concrete arch dam. H. W. RENTERSHAN. *Eng. News Rec.*, **101** [8], 268 (1928).—Describes design and construction of a brick-faced concrete arch dam. The dam is faced on both sides with vitrified brick to resist frost action and prevent surface disintegration of the concrete. W.L.

Greater efficiency in tunnel driers. W. D. RICHARDSON. *Jour. Amer. Ceram. Soc.*, **12** [12], 761–64 (1929).—Chief causes of inefficiency in waste-heat tunnel driers are (1) the cold bottom in the upper half of tunnels and (2) the hot air which enters the tunnels immediately goes to the top and does not return to the bottom but passes over the top of the ware and emerges at the receiving end of the drier only partially saturated. A method is shown of insuring a hot bottom throughout the tunnel and of recirculating the air in the tunnel by means of small fans coöperating with steel baffles on the end of every third car, these baffles registering with beams across the top of the tunnel and with pilasters on the sides, thus dividing the tunnel into compartments, with alternately up and down circulation through the ware.

Handling wet, stony clays. II. ANON. *Clay-Worker*, **92** [4], 280–85 (1929).—Two very interesting plants that have met the problem of handling wet, stony clays are located near Allentown, Pa. The materials are not the same in either plant and the two methods of handling are distinctly different. At the Nazareth Brick Co. the clay contains quantities of quartz stone so hard that it would wear out the grinding machinery in short order. After being dried in a rotary drier, the clay is fed into a Rafetto rotary-grinding and stone-separating screen. It is 7 ft. in diameter, cone shaped at each end. The quartz pebbles and stones found in the clay help in pulverizing the dried clay in this revolving, grinding, screening, and stone separating appliance. After having done their share of grinding, the pebbles and stones pass out an opening in the outlet end of the grinding screen. At the Lehigh Brick Works a red burning surface clay is used. Here the use of the rotary drier has been abandoned since high-speed rolls and a Berry one separator have been installed. The separator eliminates all stone over $^1/_2$ in. in

size. The separator consists of inclined round steel bars extending the length of the frame, between which are steel pins on sprocket chains traveling the length of the slots, thus carrying up the stone while the clay drops through the slots between the bars onto a conveyer beneath, which takes the clay to a set of high-speed rolls. Details as to other equipment of both plants are also given. For Part I see *Ceram. Abs.*, **8** [12], 883 (1929). E.J.V.

Argillaceous and siliceous products and materials. XVI. P. RENAULT. *Rev. mat. constr. trav. pub.*, No. 240, pp. 194–98B (1929).—Discussion of brick-cutting machines is continued. Several types (Nussbaumer, Pinette, Brandt) are illustrated. XVII. *Ibid.*, No. 241, pp. 218–20B.—Vertical and lateral cutters are described. For previous abstracts see *Ceram. Abs.*, **8** [12], 906 (1929). A.J.M.

Metro's new plant. ANON. *Brick Clay Rec.*, **75** [10], 622–32 (1929).—When the old plant of the Metropolitan Paving Brick Co., Bessemer, Pa., was destroyed by fire an entirely new plant was built to replace it. Not only is the machinery all new, but the design and layout of the plant is such that it reduces the labor requirement considerably below what was necessary formerly. Practically the entire plant is roller-bearing equipped. All machinery, with the exception of the represses, is individually driven by electric motors and this, with a careful study of electrical requirements, plus the use of synchronous motors on brick machines, pug mills, and fans, has resulted in a power factor of 90 to 95% without the use of capacitors or other special correcting equipment. The new plant, it is estimated, saves in power alone, approximately $7500 annually. The capacity of the plant is 750 T. daily, the equivalent of 150,000 ten-pound paving block. The details of plant equipment are given and the flow of materials is traced. Numerous photographs illustrate the special features of the plant. E.J.V.

Manufacture of brick and tile in Ohio. J. A. HODSON. *Brit. Clayworker*, **38** [450], 259–61 (1929).—H. discusses in detail the manufacture of face brick, color effects of brick, roof tile, and paving brick as manufactured in Ohio. R.A.H.

Gundorf Steam Brick Works. ANON. *Tonind.-Ztg.*, **53** [50], 884–85 (1929).—A description is given of the Gundorf Steam British Works located in Leipzig. F.P.H.

Investigations in ceramics and road materials. 1927. Can. Dept. Mines, *Mines Branch*, No. 697, pp. 1–3 (1929). HOWELLS FRÉCHETTE.—Introduction. Preliminary report on clay gathering. J. F. MCMAHON. Pp. 17–25.—Costs ranged from 19 to 68.6¢ per ton of clay, and averaged about 38¢ for 20 plants. Clays and shales of the Grand Lake Area, N. B. HOWELLS FRÉCHETTE AND J. F. MCMAHON. Pp. 26–45.—Tests on 13 samples of shales from the coal mines of this area show 12 suitable for ceramic use. Details of tests are given. Road materials in Prince Edward Island. R. H. PICHER. Pp. 46–59.—Results of a study of 16 deposits of conglomerate. Stone quarries in Quebec. R. H. PICHER. Pp. 60–67.—P. gives brief descriptions of 29 quarries. Testing non-bituminous road materials. R. H. PICHER. Pp. 68–75.—P. describes methods of making tests on bedrock for resistance to abrasion, toughness, hardness, specific gravity, H_2O absorption, cementing value, and compression; on sand and gravel for granulometric analysis, character, and shape of constituents, specific gravity, per cent of voids, abrasion, per cent of clay and silt, organic impurities, and mortar tests. Methods of sampling are described. (*C.A.*)

Firing calcareous clays. OSKAR LECHER. *Chem.-Ztg.*, **53**, 669–71 (1929).—Methods of minimizing effects of CaO in clayware are discussed. Analyses of limey clays are given. (*C.A.*)

BOOK

Mud—Its Romantic Story. RICHARD G. COLLIER. Common Brick Mfr's. Assn. Price, single copies $0.15 or $12.00 per thousand. The purpose of this booklet by the

editor of *Bldg. Economy* is to give students, writers on construction subjects, speakers, and others, accurate and entertaining information about the history of brick. The recorded age of brick is discussed, as is the history of brickmaking in America. The results of tests made at the Bureau of Standards are listed. Reviewed in *Brick Clay Rec.*, **75** [9], 566 (1929). E.J.V.

PATENTS

Ceramic compositions. HERMANN MEHNER. Ger. 472,653, July 14, 1923. A method of making porous stone from clay by high-pressure steam treatment is described. (*C.A.*)

Brick-cutter synchronizing control. GRAFTON E. LUCE. U. S. 1,732,238, Oct. 22, 1929. In combination a shaft rotatable in timed relation with and by a moving column of plastic material, a cutter for the column, power means for driving the cutter, a differential comparator driven in timed relation with the shaft and the cutter, and control means for synchronizing the column and cutter movements operable by the comparator controlling the speed of the power means to maintain a predetermined ratio of speed between the cutter and the column.

Crate for handling hollow tile, etc. JOHN J. FULLERTON. U. S. 1,733,728, Oct. 29, 1929. An apparatus for handling hollow tile, etc., in combination, a loading platform having overhanging flanges on three sides thereof, a carrying frame having coöperative flanges for engagement under the platform flanges by transverse movement of the frame, the carrying frame having a plurality of headed members thereon and the platform having corresponding notches for interlocking engagement therewith upon upward movement of the frame.

Tile block and wall construction. HARRY L. STRAND. U. S. 1,734,749, Nov. 5, 1929. In a wall construction of the type having a brick facing composed of superimposed bonded face courses of brick and a header course of brick supported in part on the face courses, a hollow building block forming a backing for the face courses and in part supporting the header course, and a T-shaped filler block comprising a relatively long portion and a shorter portion joined in the same horizontal plane and having substantially the height of the header course, the header course extending at three sides of the shorter portion of the filler block.

Method of salt glazing brick and other clay products. SIDNEY H. IVERY. U. S. 1,735,167, Nov. 12, 1929. Making a salt glaze upon coarse clay articles by applying to the surfaces to be glazed a mixture (slip or engobe) of kaolin, flint, alkali silicates of aluminium, frit, ball clay, and a color ingredient; then drying the articles and the applied mixture; placing the articles so treated in an ordinary salt-glazing kiln in such manner that the surfaces of the articles to be glazed will be exposed to the gases of the fire; firing the articles and when the firing has about reached the finishing stage and the temperature is at or near its maximum, adding common salt to the fire.

Waterproofing hollow-tile walls. WILLIAM ZAISSER. U. S. 1,735,447, Nov. 12, 1929. In a waterproofing system for hollow-tile walls, the combination of a wall constructed from dovetailed hollow tile with mortar joints between adjoining tile, a mastic coating comprising asphalt, talc, and asbestos fiber for the joints overlapping the edges of the tile, a water-proof fabric band applied to the tile to cover and seal the joints and plaster coating for the tile bonded into the dovetailed grooves and covering the band.

Forming face brick. SPENCER M. DUTY. U. S. 1,735,497, Nov. 12, 1929. In an apparatus for trimming the edges of brick, a support adapted to receive the brick as they are formed, means for cutting the edges of the brick, means for conveying the same past the cutting means, and means for imparting an irregular lateral motion to the brick while they are being cut.

Bricklaying apparatus. A. ANDRE. Brit. 317,708, Oct. 16, 1929. Apparatus to

facilitate bricklaying consists of a frame or mold suspended by hooks from crossbars in such a manner that it can be inverted to release the brick. The mold is divided by rotatable rods into compartments in which the brick are placed and then wedged by cams on the rods, or the rods may be cam-shaped. Mortar is then injected in the joints and the mold is turned over so that the flange bears on the face of the wall; if desired, the bottom of the mold may be perforated or formed as a sieve for further grouting. The mold and crossbars are then lifted to the next course level, the holes in the uprights corresponding to the courses.

Making brick. K. MAUS. Brit. 318,551, Oct. 30, 1929. Brick, slabs, etc., are molded with a hollow space which is filled with chemical substances, metal powder, or combustible materials, for example peat, the filled brick being then completely closed and fired. Combustible fillings used in this way are stated to produce hollow brick fired inside and out.

Refractories

System ZrO_2–ThO_2. OTTO RUFF, FRITZ EBERT, AND HANS WOITINEK. *Z. anorg. allgem. Chem.*, **180** [3], 252–56 (1929).—Preliminary X-ray experiments showed that there was no effect of ThO_2 on ZrO_2 up to 2100°C. Likewise X-ray diffraction patterns showed no reduction or dissociation of ThO_2 up to 2600°C. A series of 11 samples varying in composition by 10% from ZrO_2 to ThO_2 was then heated in the oxyacetylene flame. As the ThO_2 content increased the melting temperature of the mixtures increased. Therefore the authors concluded that there was formed a continuous series of solid solutions. However, X-ray diffraction patterns showed two series of solid solutions; one of ZrO_2 in ThO_2 and the other of ThO_2 in ZrO_2 with lattice constants α = 5.51 Å and 5.20 Å, respectively. Hence on cooling the melt there must be a separation into the two series shortly below the melting point. At a molecular ratio of 1:1 the authors think that there may be a compound with mean lattice constant of 5.32 Å, which is unstable. The temperature of the oxyacetylene flame is about 3100°C. By careful manipulation it was possible to melt pure ThO_2 in it so that its melting point is about 3050°C ± 25°. For preceding abstract see *Ceram. Abs.*, **8** [10], 749 (1929).

L.T.B.

Progress report on investigation of fireclay brick and clays used in their preparation. R. A. HEINDL AND W. L. PENDERGAST. Bur. Stand., *Jour. Research*, **3** [5], 691–729 (1929); see *Ceram. Abs.*, **8** [11], 812 (1929). R.A.H.

Refractories. A. B. SEARLE. *Gas Engineer*, **9**, 202–205 (1929); abstracted in *Refrac. Jour.*, **5** [49], 32 (1929).—A review is given of recent developments in refractory materials. Reference is made to the thermal expansion of fire brick, "spalling," thermal conductivity, recuperators, clay in silica brick, jointing materials, and a discussion of specifications. E.P.R.

Comparative tests on determination of reversible and permanent thermal expansion of refractories. W. MIEHR. *Tonind.-Ztg.*, **53** [49], 871–73 (1929).—This is a publication of the technical committee of the German Refractories Mfrs. relating to the methods and apparatus used in determining the reversible and permanent expansion of refractories. The results of a number of tests on shale clay, quartz-rich clay, and silica brick are given. F.P.H.

Requirements of modern refractory materials. II. A. T. GREEN. *Blast Fur. Steel Plant*, **17** [10], 1550–53 (1929).—Sillimanite, the representative formula of which is $Al_2O_3 \cdot SiO_2$ is used sometimes as a comprehensive term to include other aluminum silicates. It is the practice to add 20% plastic clay, usually ball clay as a bond. These products do not resist corrosion by ferruginous slags. Underload behavior is far superior to that of fireclay brick, and after-contraction is usually very low. Spalling resistance is quite satisfactory. Sillimanite will be useful in furnaces requiring refractories

of comparatively high melting points and good load-resisting qualities at high temperatures, but will probably be limited to operations free from slags and vapors. Where exceptional basic duties are required the use of electrically-fused magnesite is finding a scope. Fireclay products were the refractories used in the carbonization process but silica products are finding increasing application. The study of carbonizing conditions in relation to the durability of refractories can be resolved into (1) temperature variations, *i.e.*, spalling, (2) constitutional changes in the refractory or in some of its constituents, (3) coal and coke in contact with the refractory wall, (4) deposited ash, (5) burning gases in the combustion chamber, and (6) local circumstances, including features in the design and erection of the installation. In the use of silica products for retort work great care must be taken in the control of the product. It is essential that (1) texture be fine, (2) firing be such that the specific gravity and after-expansion are reduced to an economic minimum. Much of the early difficulty in the use of this product was associated with the "growth" of the retort during working. This phenomenon results from the presence of unconverted quartz in the original material. This was transformed into the other forms during usage with consequent expansion thrusts which often disintegrated the retort. Owing to the large expansion of silica products at low temperatures the greatest care in the initial heating of a silica retort setting or coke oven is necessary. If the rate of heating is excessive or irregular the danger of spalling or the introduction of strains into the installation is intensified. F.P.H.

Properties and tests of refractories used in metallurgy. P. GILARD. *Rev. mat. constr. trav. pub.*, No. 241, pp. 213–17B (1929).—Various properties and tests are presented. The refractories may be arranged as follows in the order of increasing thermal expansion (0 to 900°C): calcined bauxite, clay, chromite, magnesite, and silica; see also *Ceram. Abs.*, **8** [12], 891 (1929). A.J.M.

Radiation heat transmission for formulas. O. A. SAUNDERS. *Proc. Phys. Soc.* [London], **41** [5], 569–75 (1929).—The general expression for the radiation heat transfer from a surface is first considered, after which some simple cases are examined, *i.e.*, parallel planes, concentric spheres, etc. Some general conclusions are drawn for the case of a surface completely surrounded by other surfaces at a uniform temperature but of no particular simple shape. It is pointed out that whatever the shapes, sizes, and relative positions of the various surfaces, the heat transfer per unit area must always lie between minimum and maximum values depending only upon temperatures and emissivities. An approximate formula is given for the heat transfer when the surroundings are poor reflectors; this is applied to two non-concentric spheres, one within the other. T.W.G.

Forms of zirconium dioxide. OTTO RUFF AND FRITZ EBERT. *Z. anorg. allgem. Chem.*, **180** [1], 19–41 (1929).—The X-ray diffraction pattern of zirconium dioxide heated to various temperatures up to 2600°C always showed a monoclinic form. By using a special apparatus for obtaining diffraction patterns of the material at high temperatures, it was found that there was a reversible change of modification at 1000°C from monoclinic to tetragonal form. The lattice constants of these forms are: Monoclinic: a = 5.17 Å; b = 5.26 Å; c = 5.80 Å; α = 80.8°; density = 5.68; $a:b:c$ = 0.975:1:1.01. Tetragonal: a = 5.07 Å; c = 5.16 Å; density = 6.10. *System ZrO_2–MgO.* When the amount of magnesia was more than 46 molecular per cent the lines of free magnesia could be detected in the diffraction pattern of the samples besides the pattern of a crystal form of cubical structure of the fluorite type. This cubical structure was present until the amount of magnesia was less than 4 molecular per cent when the monoclinic ZrO_2 again appeared. The last-named samples showed the change to tetragonal ZrO_2 at 1000°C. It is this change which causes ceramic bodies of ZrO_2 to crack and disintegrate when heated. The cubical structure present when MgO is in excess of 4% does

not change modification and hence bodies of such composition are volume constant. To obtain this cubical structure the bodies must be heated above 1300°C. Samples containing 10 molecular per cent MgO, when heated between 1300 to 1400°C, yield a product which is easily ground and is highly plastic when wet. ZrO_2 when heated with certain other oxides will form a cubical structure when heated to about 1700°C. Such oxides are those which possess a cubical structure, besides the ionic radii of the metallic element must be less than or about equal to that of Zr^{+++}. Among such oxides are CaO, Sc_2O_3, Y_2O_3, and CeO_2. Cubic oxides with ionic radii considerably greater than that of Zr^{+++} will not prevent ZrO_2 from undergoing the monoclinic-tetragonal change. Among these oxides are BaO, SrO, and FeO. The authors assert the existence of a compound $2MgO{\cdot}3ZrO_2$ which is the end member of a solid solution series of MgO in ZrO_2, because: (1) A fluorite structure demands the existence of 8 O-atoms in the unit cell. (2) Only when the amount of MgO is greater than the percentage in this compound does the diffraction pattern of free MgO appear in the system. (3) On extraction with H_2SO_4, the residue always contained MgO and this residue showed this fluorite structure. (4) Molecular weight determinations from X-ray data on this cubical material gave values of 450 to 457. The molecular weight of the compound is 450.3. (5) Density determinations on this cubical material from X-ray data gave values of 5.7 to 5.8. This cubic structure was never present in the pure system ZrO_2 up to its melting point. L.T.B.

Silica as a refractory. R. B. Sosman. *Refrac. Jour.*, **5** [49], 2 (1929); *Iron Age*, 1554–56 (1929); for abstract see *Ceram. Abs.*, **8** [8], 585 (1929). E.P.R.

Carborundum. J. A. King and B. H. Snow. *Can. Chem. Met.*, **13** [11], 28 (1929).—Silicon carbide has a specific gravity of 3.23, at 15°C and takes the form of fine blue, green, or brown crystals, sometimes transparent, sometimes opaque. It is infusible and unaffected by heat up to 2220° C. The raw materials used in the production of this material are silica sand, 54.2%, coke 34.2%, sawdust 9.9%, and common salt 1.7%. Silicon carbide is used both in powder form and in wheels and blocks, being mixed with wet, fine clay, and feldspar, molded and pressed. Carbofrax (an amorphous carbide), formerly considered a waste product of silicon carbide has been successfully used for lining steel furnaces, having splendid refractory qualities, high heat conductivity, and great mechanical strength. E.J.V.

Refractory materials. Anon. *Rev. mat. constr. trav. pub.*, No. 240, pp. 199–204B (1929).—Argillaceous, siliceous, aluminous, magnesia, calcareous, chrome, silicon carbide, and zirconia refractories are discussed. A.J.M.

Russian magnesite on international market. B. Birnkow. *Tonind.-Ztg.*, **53** [52], 928–30 (1929).—Chemical composition and physical properties of various brands of magnesite exported from Russia are discussed. F.P.H.

Chromite, its mineral and chemical composition. Lloyd W. Fisher. *Amer. Mineralogist*, **14** [10], 341–57 (1929).—The mineral called chromite is a member of the spinellid group of minerals which crystallize in the isometric system. The spinellids have the general formula R″ O R″ ′203. Chromite, however, is seldom found as a pure double oxide. Replacement of FeO by MgO and Cr_2O_3 by either or both Al_2O_3 and Fe_2O_3 gives rise to varietal types and chief among these are chrompicotite, chromhercynite, magnesiochromite (mitchellite), picotite, and chromiferous spinels. The mineral called chromite can seldom be expressed by a definite formula. It is usually a mixture of the varietal types cited. There is a strong probability that the spinellids, magnetite, magnesioferrite, and others enter into its chemical makeup. The chemical compositon of the mineral called chromite is roughly indicated by the color of the mineral in thin section. Low chromic oxide content, as in picotite, is characterized by a yellowish brown translucency, and high chromic oxide content by a deep cherry-red to coffee-brown color.

Anastomosing black opaque lines traverse translucent chromite grain and indicate either (1) presence of a foreign substance which may be present as a solid solution in the mineral, or (2) iron oxide deposited as a cement along narrow or incipient fractures.
F.P.H.

Occurrence of dumortierite near Quartzite, Arizona. ELDRED D. WILSON. *Amer. Mineralogist*, **14** [10], 373–81 (1929).—In 1927, claims were located on certain dumortierized schist outcrops near Quartzite, about 45 miles north-northeast of the Clip locality. These outcrops represent the first-known Arizona occurrence of the mineral. The deposit is of further interest because the three isomeric aluminum silicates, andalusite, cyanite, and sillimanite, are associated with the dumortierite, and show alteration to pyrophyllite instead of to muscovite. Associated with the dumortierite are quartz, cyanite, andalusite, sillimanite, pyrophyllite, muscovite, hematite, magnetite, rutile, leucoxene, pyrite, limonite, sapphirine (?), and some undetermined species. No accurate analysis was attempted to determine the percentage of dumortierite in the richest rock. Its specific gravity, however, as determined by a Jolly Balance, is about 2.73, which, neglecting minor accessory minerals, would fit a composition of 11.11% dumortierite and 88.89% quartz, if the gravity of the quartz be taken at 2.66 and of the dumortierite at 3.30. Microscopic examination shows this blue rock to consist primarily of allotriomorphic crystals of quartz, from 0.1 to 0.75 mm. in diameter, cut by a few quartz veinlets of larger grain. F.P.H.

Status of magnesite industry in U.S. J. M. HILL. *Eng. Mining Jour.*, **128** [2], 48–51 (1929).—For the period 1913 to 1926 the average production of crude magnesite in the world was about 500,000 metric tons per year. Tables and graphs of world production of magnesite from 1913 to 1926 are given. The sale, import, consumption, and production of crude, calcined, and dead burned magnesite over years 1922 to 1927 for U.S. are also tabled. The use of magnesite for stucco and building material is declining but its use as a refractory is rapidly increasing. E.C.C.

Haglund method of manufacturing alumina. ASSAR GRÖNWALL. *Tek. Tid. Kemi*, **59**, 93–96 (1929).—Impurities in bauxite are removed by addition of sulphide-containing materials and reducing in an electric furnace. Pure Al_2O_3 crystallizes on cooling. The slag contains all foreign metals and some Al_2S_3, which is later decomposed with H_2O to regain Al_2O_3. This method is more economical than all older methods, and can be applied to bauxite containing more SiO_2 than can be allowed in these. One ton of Al_2O_3 requires 4500 kw.-hrs. The furnace is lined with square C electrodes, which are not corroded by Al_2S_3. Water-cooled Cu pipes are used for electrical conductors. (*C.A.*)

Preparation of pure alumina from Tikhvin bauxites. I. LILEEV. *Trans. State Inst. Applied Chem.* [Moscow], No. 8, pp. 14–38 (1927).—Three samples of Tikhvin bauxite contained (1) 17.4, 40.6, 23.5; (2) 7.6, 63.5, 14.0; (3) 5.0, 74.5, 5.7 of SiO_2, Al_2O_3, and Fe_2O_3, respectively. Al_2O_3 used for the manufacture of Al should not contain over 0.3% SiO_2 and 0.1% Fe_2O_3. Methods of purification were investigated. Packard's process (Ger., 182,444) gave very good results with 1. Up to 90% Al_2O_3 was extracted and the unused Na_2CO_3 was only 4%. This process is inapplicable to 2 and 3, which have a greater Al_2O_3 content, because the reactions do not take place according to the equations given by Packard, but are $Na_2CO_3 + Al_2O_3 = 2NaAlO_2 + CO_2$; $Fe_2O_3 + Na_2CO_3 = 2NaFeO_2 + CO_2$. At 800 to 900° CaO reacts with SiO_2 and kaolin reacts with Na_2CO_3 to form an insoluble aluminosilicate, only 12% of the kaolin decomposing into Na_2SiO_3-$NaAlO_2$ and dissolving in H_2O. To obtain good results with these reactions it is necessary to use 1 molecule Na_2CO_3 per molecule Al_2O_3 and 1 molecule Na_2CO_3 per molecule Fe_2O_3. Also, the ratio between Na_2CO_3 and $CaCO_3$ should be about 1.5:2. It is important that all ingredients be well ground and thoroughly mixed, then calcined at 875

to 925° in an oxidizing atmosphere, so that the Na_2CO_3 reacts completely with Al_2O_3 and to only a slight extent with kaolin. Unless calcination is done in such an atmosphere Fe and Cr oxides form, contaminating the aluminates. Washing with H_2O must be done at 90°, as at ordinary temperatures a large amount of SiO_2 compounds dissolve. Filtration of the alkaline solution gives no trouble. To separate crystallized $Al(OH)_3$ fractional precipitation may be used. The solution must be 35° Bé and 60 to 90°. The 3 fractions contain up to 0.1%, up to 0.3%, and above 0.3% SiO_2, respectively. The remaining solution solidifies and can be reused as Na_2CO_3. Under the above conditions 85 to 90% of the Al_2O_3 is extracted from the bauxites. (*C.A.*)

Transformation products of quartz. H. Winter and R. Hupe. *Glückauf*, **64**, 1556–59 (1929); *Chem. Zentr.*, I, 373 (1929).—Natural quartzite, quartzite heated 4 hrs. at 1550° and 2 coke-oven stones, which had been in use for a long time, were examined between 120° and 1000°. With the first material, the curve showed distinct breaks at 560° and 580°, respectively (transformation α- into β-quartz). Other breaks were observed between 860° and 880° (β-quartz into β-tridymite). The curve of the previously heated quartzite was irregular between 100° and 280° (α- into β-tridymite, β_1- into β_2-tridymite and α- into β-cristobalite). The quartz break at 560° was still present and also the break at 870°. The coke-oven stones also showed the cristobalite and tridymite transformation between 100° and 280°, and the quartz break at 580° could be observed likewise, which means that despite their long use in the coke oven, quartz is still present in them. The transformation of quartz into tridymite could be demonstrated again at 880°. (*C.A.*)

Refractory and corrosion-resistant materials used in Germany in the manufacture of chemical apparatus. B. K. Klimov. *Trans. State Inst. Applied Chem.* [Moscow], No. 12, pp. 3–115 (1929).—An apparatus exhibited at the 5th German Exposition of Chemical Apparatus is described. Analyses are given of refractory silicates and tests are made of the action of various corroding reagents on ebonite, steel, cast iron, silica, and other specially prepared apparatus materials. Krupp's refractory steels for pipes conveying liquids at high temperature in chemical manufacture analyzed thus: P 0.33, Ni 20.99, Cr 22.92, Si 1.2, S 0.075, Mn 1.2, C 0.22, and Fe 53.36%. These steels have a tearing resistance of 60 to 70 kg. per sq. mm., an elongation of 44 to 50%, do not rust even in sea water, resist all acids, except concentrated HCl and H_2SO_4, are refractory up to 1000 to 1300°, have no magnetic properties, cannot be tempered, and possess a good malleability in the cold state. (*C.A.*)

Refractories service conditions in furnaces burning anthracite on traveling grate stokers. R. A. Sherman, Edmund Taylor, and H. S. Karch. *Trans. Amer. Soc. Mech. Eng.*, **51**, 183–96 (1929).—Data obtained under actual operating conditions are presented on the service conditions which govern the life of refractories in furnaces. Temperature, composition, and velocity of furnace gas, temperature of refractories and amount and compositions of the solids carried in the furnace gas were investigated. The nature of the slag action was studied. The investigation disclosed no reason why, with the proper design of furnace to obviate the extremely high temperatures and high content of reducing gas, the burning of anthracite of the sizes smaller than buckwheat No. 3 should be accompanied by more difficulty with refractories than the burning of the larger steam sizes. (See also *Ceram. Abs.*, **8** [12], 886 (1929).) (*C.A.*)

Refractories. F. Th. H. Rauch. *Proc. Soc. Chem. Ind.* [Victoria], **27** [1–4], 1326–44 (1927); for abstract see *Ceram. Abs.*, **8** [12], 890 (1929). (*C.A.*)

New refractory building materials. Anon. *Tonind.-Ztg.*, **53** [56], 997–99 (1929).—A number of new refractory shapes are described and illustrated. F.P.H.

Sagger investigation. Anon. Bur. Stand., *Tech. News Bull.*, No. 150, pp. 94–95

(1929).—Among the results obtained from a study of a series of sagger bodies it was found that the porosity of the fired sagger body bears a very important relation to the resistance of saggers prepared from it to failure from heat shock. In order to determine the range in porosity most effective toward prolonging sagger life a systematic study has been undertaken of a series of sagger bodies which have been fired at different temperatures so as to give a range in values for this property. Thirty-eight different bodies have been prepared from clays and grogs of known properties and 300 small oval saggers and 425 specimen bars were made from them and fired. A number of each body were fired at cones 8, 10, and 12. The bodies are tested for resistance to thermal shock, elasticity, and strength at various temperatures and porosities. R.A.H.

Economies in crucible manufacture. E. PROBST. *Sprechsaal*, **62** [14], 243–44 (1929).—Cost can be reduced by (1) saving of raw materials and wages, (2) circumventing sources of fault and loss in manufacture, and (3) economical processing and utilization of all conceivable advantages in manufacture. (1) Selection of proper bond clay that permits sufficient non-plastics is important. It must be refractory, shrink little, and have mechanical strength at high temperature. Clay should become dense but not glassy at low temperatures. Graphite is added to obtain resistance to molten metal. Because of their greater conductivity, crucibles become more resistant to sudden temperature changes. They also become smoother which facilitates pouring. Flaky graphite is best and thorough machinery mixing places the flakes parallel. (2) Faults are caused by faulty selection of raw materials and improper preparation, forming, drying, and firing; this is evidenced by hair cracks, checking, and air blisters, and is mostly due to insufficient mixing. Uniformity in pressing, wall thickness, and density are the results of intimate mixing. (3) Repeated auger machine treatment with aging is expensive and time-consuming. Most intimate mixing and blending of raw materials by machinery is recommended in pans or twirling machines or mixers of the countercurrent principle. T.W.G.

Production of glasshouse refractories. ANON. *Amer. Glass Rev.*, **49** [4], 13 (1929).—The glasshouse clay products had a value of $2,993,609 in 1928 as compared with $2,310,473 in 1927. The quantity in 1928 was 35,513 as compared with 41,177 in the previous year. E.P.R.

Durability of lining of direct arc furnaces under various operating conditions. E. KOTHNY. *Feuerfest*, **5** [1], 1–3 (1929).—The article is the summary of a report of a committee of the German Foundry Assn. It contains data from a large number of foundries collected during the course of operation. The durability of the lining is measured in hours of operating life. *Durability of roof lining.* A silica brick was used in all cases reported. The manner in which the brick was bound, by wet or dry methods, had no effect on durability. Increase in thickness of the brick tended to increase durability, yet it is uneconomical to increase them beyond a certain limit; by considering all factors 250 mm. seemed to be the most economical thickness to use. Under the same operating conditions the height of the vault crown above the furnace bed had no effect. *Durability of wall lining.* Data from various types of brick and types of construction are included. In the case of magnesite brick, dry binding seemed better than wet binding. Stamping of powdered magnesite to form the wall gave a longer life than the use of magnesite brick. An increase in the number of runs within a given period, rather than one continuous run, caused a decrease in the life of the lining. Likewise an increase in the current at which the furnace was operated decreased durability. *Durability of the bottom lining.* From the varied results reported no definite conclusions could be drawn as to durability of the bottom lining. The report emphasizes the fact that the use of high-grade materials and good workmanship in the construction of the furnaces are by far the most important considerations. L.T.B.

Refractories in steel furnaces. O. PHILLIP. *Feuerungstechnik*, **17** [8], 91–93 (1929); *Refrac. Jour.*, **5** [49], 32 (1929); for abstract see *Ceram. Abs.*, **8** [7], 507 (1929). E.P.R.

Temperatures and pressures in the coke oven. ANON. *Gas Age-Rec.*, **64** [16], 565–68 (1929). F.P.H.

Refractories and the coke oven. HAROLD SHAW. *Refrac. Jour.*, **5** [49], 10–11 (1929).—Fireclay brick at 1350°C collapse under load. Semisilica is unsatisfactory for oven construction, hence a modern coke oven is built almost entirely of "straight" silica brick. Although silica ovens are expensive, the additional cost is offset by increased life. The jointing material must be similar to that of the brick themselves. It is well known that silica expands considerably at the very low temperature of 150°C and approximately half the total expansion has taken place below 300°C, hence the setting into operation of a new coke-oven battery calls for great care. A diagram shows the process in the heating up of ovens of a silica structure. Any departure from this practice may lead to serious cracks in the brickwork of both the oven and regenerator walls, permitting leakages of gas and air. E.P.R.

Refractory materials: their uses in vertical retorts. A. T. GREEN. *Refrac. Jour.*, **5** [49], 3–8 (1929).—In the carbonizing industries there is a marked trend toward the use of silica products for the retort proper and in the combustion chambers where the higher temperatures are the rule. A superior silica brick, under a load of 50 lb./sq. in. and in the circumstances of the test, may show no appreciable subsidence up to temperatures in the neighborhood of 1650°, when rapid collapse will take place. A fireclay product may start to show a gradual subsidence between 1200° and 1250°, with a fairly rapid collapse between 1350° and 1400°. A pocket-sand siliceous product possesses structural ability under this load up to temperatures between 1530°C and 1600°C. After testing at high loads the silica brick after collapse usually show a "shear" fracture, whereas, in this test, the fireclay product tends to squat. The "silica fire brick," the basis of which is the pocket sand found mainly in isolated pits in the carboniferous limestone of Derbyshire, falls between the two previously mentioned categories of common refractories. Those changes which occur during the firing of refractory materials are discussed in detail. In studying the various influences militating against the economical life of a retort it is advisable to bear in mind (1) limitations in the properties of refractories under general carbonizing conditions, (2) individuality of the carbonizing system, (3) probable local peculiarities in operation, and (4) the nature and influences of the coal used. In continuous vertical retort work one ideal is the continuous unhampered descent of the charge through the retort. Strains can be set up in a refractory structure during usage by (1) temperature variations, (2) alterations in the nature and constitution of the refractory, (3) deposition sometimes followed by crystallization or solidification of foreign substances in pores of bricks, or (4) a combination of such circumstances. In the upper portions of vertical settings, spalling is sometimes encountered. Foreign substances, such as iron compounds and alkalis, pass from the coal into the pores of the refractory in a volatile form. This is followed by deposition and either crystallization or an interaction with the constituents of the refractory giving rise to severe and highly localized strains. Steam is a very effective reducing agent, intensifying slagging or eroding action of iron oxide. Jointing cement should be uniform in texture, finely ground, and should possess a certain plasticity to enable very thin joints to be made. The zonal nature of vertical retort working suggests that the constitution of a cement must vary with the zone of the retort. (See also *Ceram. Abs.*, **8** [9], 660 (1929).) E.P.R.

Silica retorts. W. E. DEAN. *Refrac. Jour.*, **5** [49], 30–31 (1929).—The retort settings, as originally installed, were of ordinary fireclay material, but time proved these to be unsatisfactory owing to the high heats. Experiments were made with retorts of

siliceous material, but without success, then two silica segmental retorts were put in the middle of the setting. The two retorts were put to work in October, 1924, and have since been in constant use. Due to their being able to withstand the high temperatures and retain their shape, and owing to the additional support given to the side retorts which are manufactured of siliceous material, the life of the setting has been increased considerably. Stephen Hay, in his paper before the Assn. in 1927, proved that silica gives a longer life than fire clay under conditions existing at Becton, and many other engineers have stated in a general way that silica settings are more durable under modern conditions than fire clay. The main advantages of silica over fire clay are (1) maintenance of shape at high temperatures, (2) increased rate of carbonization and throughput, (3) more easily scurfed, (4) larger charges may be adopted, and (5) less cracking occurs. E.P.R.

Furnace construction and refractories at the "Gas and Water" Exhibition in Berlin. L. LITINSKY. *Feuerfest*, **5** [9], 149–57 (1929).—A report of the exhibition and the products displayed there. The article is illustrated with 19 photos of exhibits. L.T.B.

Repairing blast-furnace shafts without completely shutting them down. A. COUSIN. *Rev. métal.*, **26**, 395–400 (1929).—In use, the top and especially the middle portion of blast-furnace shafts, gradually wears down, in proportion with the rate of output of the furnace, while in the bottom of the shaft a protective coating of CaO forms, which is infusible at the working temperature of the furnace. If the furnace is completely shut down for repairs, this protective coating slakes and crumbles in contact with moist cold air, so that it is necessary to rebuild the bottom portion of the furnace as well as the shaft, which generally requires several months. After the shaft wall has worn down considerably, the charge serves as a support for the wall, and if the charge is lowered below the level of the worn portion, there is danger of the wall collapsing. In order to prevent this the Cockerill Co. has devised a system of external reënforcement for supporting the shaft and at the same time permitting ready accessibility for repairs. To effect repairs, the charge is allowed to fall to a level about 2 m. below that place where repairs are to be made. The company in this way reconstructed the entire shaft of a 250-T. furnace in 8 days (with complete shutdown, the work would have required several months), and the repaired furnace has been in satisfactory operation since March 2, 1926. (*C.A.*)

Kier Fire Brick Co. ANON. *Brick Clay Rec.*, **75** [9], 550–60 (1929).—One of the pioneers in the movement to modernize plants, cut production costs, and increase the quality of products was the Kier Fire Brick Co., Salina, Pa. This company was one of the first to remodel its plant with the tunnel kiln units and dry-pressing processes. The periodic kilns have been replaced by two Harrop car tunnel kilns having a kiln capacity of 325,000 brick per week of seven days. The entire plant and process of production has been remodeled. A detailed description of the new plant equipment and the step-by-step production methods are given. Kiln temperatures range from 2300 to 2400°F with 23 rare metal thermocouples and 11 base metal couples in each kiln to keep an accurate record of the temperatures. E.J.V.

West-German refractory industry. HECK. *Tonind.-Ztg.*, **53** [49], 875–76 (1929). F.P.H.

Electrical conductivity of magnesite and some other refractory materials in relation to the temperature and their other properties. E. DIEPSCHLAG AND F. WULFESTIEG. *Iron Steel Inst.*, 24 pp. (1929).—The electrical resistance of calcined magnesite falls rapidly with rising temperature, the fall becoming slower at high temperatures, though a constant curve does not exist due to the internal variability of the material, previously fired and unfired materials showing great differences in resistance. To obtain stable

experimental conditions a minimum firing time of 26 hrs. at 1550° was required. Increase in pressure when manufacturing the specimens reduces resistance, due probably to reduction in the size of pores. Light oxides, *e.g.*, magnesia, silica, alumina, and lime have nearly straight-line curves above 1500°, whereas the curves for dark oxides such as those of iron (Fe_2O_3) and manganese (Mn_3O_4) drop suddenly at lower temperatures; the resistance curves of the light oxides are in the order given above. The addition of white oxides tends to lower the resistance of common magnesite. (*B.C.A.*)

BOOK

Non-Plastic Ceramic Materials: Grog, Fluxes, and Refractories. (German.) RUDOLF NIEDERLEUTHNER. 577 pp. Julius Springer, Vienna, 1928. Price 39 Rm.—Reviewed in *Chem. and Ind.*, **48**, 1041 (1929); for abstract see *Ceram. Abs.*, **8** [3], 233 (1929). H.H.S.

PATENTS

Producing pure aluminum hydrate particularly from aluminum-containing raw materials rich in silica. ERIK LUDVIG RINMAN. U. S. 1,732,772, Oct. 22, 1929. Process of producing pure aluminum hydrate, particularly from aluminum-containing raw materials rich in silica, which consists in treating the aluminum-containing raw material with sulphuric acid for producing aluminum sulphate solution, treating the aluminum sulphate solution with sodium sulphydrate solution for producing impure aluminum hydrate and sodium sulphate and hydrogen sulphide, separating the sodium sulphate and hydrogen sulphide from the impure aluminum hydrate, dissolving the impure aluminum hydrate in sodium sulphide solution so as to form sodium aluminate and sodium sulphydrate, filtering off undissolved residue, and precipitating pure aluminum hydrate from the mixed sodium aluminate and sodium sulphydrate solution obtained by treating the solution with hydrogen sulphide and separating such pure aluminum hydrate from the sodium sulphydrate solution formed.

Bonded refractory. JOHN D. MORGAN. U. S. 1,734,595, Nov. 5, 1929. Method of making refractory articles from a mixture of zircon and monazite sand comprising treating the mixture with a mineral acid and firing the mixture.

Making refractory product. ISAAC HARTER AND ANTHONY M. KOHLER. U. S. 1,734,726, Nov. 5, 1929. Refractory article comprising particles of alumina-silica material having greater alumina content and higher melting point than kaolin and fired at a temperature of at least 90% of the melting point temperature of the material, the particles being bonded by alumina-silica material of a melting point at least equal to kaolin and fired at a temperature of not less than 3000°F.

Flexible tie for plastic furnace linings. SAMUEL C. GILBERT. U. S. 1,736,704, Nov. 19, 1929. Means for anchoring plastic linings to furnace walls, comprising in combination a member adapted to be secured to a furnace wall, a chain one end of which is adapted to be embedded in a plastic lining for the wall and means for connecting the member to the other end of the chain whereby the plastic lining is maintained in close proximity to the furnace wall but is permitted to move in expanding and contracting through short distances in directions parallel to the wall without cracking or bulging.

Refractory substances. HARBISON-WALKER REFRACTORIES CO. Brit. 317,449, Oct. 9, 1929. Serpentine is made suitable for use as a refractory material by being calcined at a temperature high enough, about 2900°F, to drive off its volatile constituents and reduce its porosity below 20%. The calcined clinker is ground and may then be made into brick by being mixed with lignum liquor and molded, or by being mixed with water, molded and fired at a temperature about 100°F lower than the calcining temperature. The serpentine may be blended with magnesite to modify the refractory qualities of the product.

Furnace roofs. A. REPPMAN. Brit. 317,889, Oct. 16, 1929. A furnace roof of the single layer suspended brick type is built up of pairs of blocks having parallel faces at an angle to the plane of the roof. The supporting members may be of I-beam, tubular or wedge form, and in adjacent courses the direction of the blocks is reversed. See also E. STRUNK, *Ceram. Abs.*, **7** [4], 239 (1928).

Furnaces. LIPTAK FIREBRICK ARCH CO. Brit. 318,581, Oct. 30, 1929. Furnace arches of the kind described in Brit. 143,972 are provided with intervening spaces between the upper and lower rows of blocks to contain water tubes for cooling the arch and supplying the boiler. In arches having an upwardly extending inner end portion the tubes are carried therethrough. A number of nozzles extend through the front of the arch for discharging air under the arch.

Furnace walls. A. P. THURSTON. Brit. 318,695, Oct. 30, 1929. Walls comprising water tubes and interposed tile have the tile formed with wings to fit against the tubes against which they are secured by clamps having diverging edges to engage with the tile. The clamps are pressed against the tile by nuts on bolts welded to the tubes. The tile have a metal back faced with refractory material on the furnace side.

Plastic compositions. A. P. THURSTON. Brit. 318,696, Oct. 30, 1929. To a moderately refractory water-glass cement of high heat conductivity for furnace linings, containing pulverulent metal, metallic oxides, such as iron, copper, silicon carbide, hematite, copper oxide, etc., glycerine and oil are added to prevent drying before use. *E.g.*, 100 parts silicon carbide, 40 parts water-glass, 20 parts glycerine, and 2 parts castor oil are used.

Alumina. ELEKTRIZITÄTSWERK LONZA. Swiss 130,145, Aug. 4, 1927. Fused alumina is finely divided by rapid cooling, as by spraying into water. See following abstract. (*C.A.*)

Alumina. ELEKTRIZITÄTSWERK LONZA. Swiss 131,590, Aug. 4, 1927. Molten alumina is finely divided by spraying it under pressure into the path of a strong current of atomized water. See preceding abstract. (*C.A.*)

Alumina. I. G. FARBENIND. A.-G. Ger. 479,768, Oct. 14, 1924. Fe-free alumina is obtained from clay by treating with HCl, reducing the $FeCl_3$ to $FeCl_2$, evaporating the solution of Fe and Al chlorides and decomposing the $AlCl_3$ thermally. The $FeCl_2$ is then extracted. (*C.A.*)

Ceramic compositions. STERCHAMOLWERKE G.M.B.H. Ger. 480,586, Oct. 21, 1925. Porous fire brick are made by mixing the clay with material which is swollen by water, *e.g.*, cork dust, before molding, and burning it out after molding. (*C.A.*)

Terra Cotta

Investigations in durability of architectural terra cotta and faience. W. A. MCINTYRE. Dept. Sci. Ind. Research, *Bldg. Research Special Rept.*, No. 12 (1929); for abstract see *Ceram. Abs.*, **8** [10], 752 (1929). E.J.V.

Modern building art and ceramics. FRIEDRICH LIPINSKI. *Keram. Rundschau*, **37**, 147–49 (1929).—Examples of bas-reliefs in architectural terra cotta are described and illustrated. H.I.

Origin of tile stoves. MICHAEL BIRKENBIHL. *Keram. Rundschau*, **37**, 95–97, 128–29 (1929). H.I.

Salt glaze. II. BERNHARD NEUMANN. *Sprechsaal*, **62** [42], 767–70; [43], 787–89 (1929).—This second installment gives further proof of statements made in Part I (see *Ceram. Abs.*, **8** [12], 899 (1929)), and is accompanied by enlarged photos showing salt-glaze structures on sewer pipe and stoneware. T.W.G.

Salt glazing. FELIX SINGER. *Chem. Fabr.*, **26**, 309 (1929).—Some passages of

S.'s book "Stoneware" (see *Ceram. Abs.*, **8** [11], 851 (1929)) are quoted in reference to salt glazing. While all kinds of glazes may be used on stoneware, the salt glaze is exceptionally well adapted. Salt is evaporized in the furnaces causing dissociated sodium-chloride vapors throughout the kiln. The chemical reaction between Na_2O and the clay body causes a very thin but thoroughly knitted layer of glass. T.W.G.

Rhenish stoneware. A. HANKE. *Keramos*, **8** [18–19], 695–712 (1929).—A general discussion is given of the present condition of the Rhenish stoneware industry. F.P.H.

Methods of fixing roofing tile and their influence on tile lamination. LESLIE G. TOMLINSON. *Brit. Clayworker*, **38** [450], 255–59 (1929).—Laminations in tile may occur through any one of a number of causes or through a combination of two or more causes. Such causes may be as follows: (1) Clay is not suited for tile making. Vitrified tile sweat more than porous tile, but over-porosity is a disadvantage in that it may be the cause of leaky roofs and in addition is at the root of most fungus troubles. General opinion is that porous tile stand up better than vitreous and add to the ventilation of the roof. (2) The presence of lime in clay may cause trouble. Clay containing lime may be cured if sufficiently weathered. (3) The method by which tile are made is of prime importance since every clay has to be treated individually and what suits one clay will not necessarily suit another. (4) Underfired tile. There can be no standard temperature or system of firing tile. The best firing procedure for any particular clay is obtained only by experience. In fixing tiles attention must be given to not only the durability of the tile but more particularly for the purposes for which they are to be fixed. Two factors which exert considerable influence in roofing are pitch and gage. A tile roof of flatter pitch of more than 105° at apex will dry slowly and as it retains moisture longer is more liable to flake. Ninety degrees is a good pitch. Lap and gage are also important. Maximum gage should be 4 in. giving an overlap of $2^1/_2$ in. with $10^1/_2$ in. by $6^1/_2$ in. in tile. Approximately $^1/_4$ in. camber or housing in the length of the tile is required. The following methods for fixing tile are discussed in detail: (*a*) The tile are laid dry on the tiling laths which are laid across the rafters. (*b*) The tile are laid dry on laths as in (*a*) and torched, underdrawn, or pointed with a good hair mortar. (*c*) The roof is close boarded and sarked with a good nonconducting felt, the nibs are knocked off the tile which are then nailed on top of the felt dry. (*d*) The roof is close boarded and sarked as in (*c*), the usual tile laths are fixed in, between which mortar is filled. The tile are then hung by their nibs on the laths and are bedded solid in the mortar. (*e*) The roof is prepared as in (*c*), vertical battens, size about 2 in. by 1 in. or $^3/_4$ in. are nailed through the felt and boards over the center line of the rafters. The tile laths are wired across these and the tile hung by their nibs on the laths dry. (*f*) The tile are laid dry on the laths and the underside of the rafters is sheeted with good strong waterproof paper. R.A.H.

BOOK

Noise in Buildings (French). T. KATEL. Librairie Polytechnique, C. L. Beranger, Paris, 1929. Price 15F.—The chief sections of the book are on what constitutes important sounds, transmission of sound through porous and nonporous bodies, suppression of noise and vibrations at their source, sound insulation of machinery, and sound reflection and reverberation in closed spaces. Reviewed in *Engineering*, **128**, 475 (1929).

H.H.S.

PATENT

Molding ceramic bodies. HERMSDORF-SCHOMBURG-ISOLATOREN GES. Brit. 317,364, Oct. 9, 1929. Ceramic bodies, particularly of large dimensions, are formed by uniting turns or windings formed from one or more strands of material. A strand fed from a press is received upon a rotary table and wound about a core in superposed turns which are united by pressure or by the aid of slip. The turns may be superposed on the

interior of a hollow former, or without a former. Flat objects are formed by laying the turns side by side instead of superposing them. Both methods may be combined. More than one strand may be employed and the thickness of the strand may be varied.

White Wares

Technical advances in fine ceramics in 1928. W. STEGER. *Keram. Rundschau*, **37**, 19–24, 38–40 (1929).—Papers describing new compositions, methods of preparing ceramic raw materials and products, and new methods of measuring and testing are reviewed. H.I.

Glost warping of white wall tile. T. DWIGHT TEFFT. *Jour. Amer. Ceram. Soc.*, **12** [12], 765–70 (1929).—Method for measuring warpage of wall tile is presented and a study is made of the warping results obtained from variations of glaze composition. Conclusions are drawn from tests with zinc oxide, calcium, barium, and magnesium.

Fritted glazes. C. STÜRMER. *Keram. Rundschau*, **37**, 164–67 (1929).—Use of NaCl in fritted covering glazes aids in lowering the fusion temperature of the glaze and in eliminating or reducing the color due to iron. Less than 40% of the NaCl is volatilized during the melt. H.I.

Porcelain industry in France. ALDEN WELLES. *Crockery Glass Jour.*, **107** [11], 23 (1929).—The article is a story of a discovery which led to the production of famous china. In the year 1765 a good quality of kaolin was discovered near Limoges, France. This was the beginning of the porcelain industry in European countries. E.P.R.

Belleek, the only Irish porcelain. ANON. *Int. Studio*, **94** [390], 50 (1929).—The outstanding features of Belleek ware are its eggshell thinness, due to the excellent local clay (fine kaolin with large percentage of feldspar) and the mother-of-pearl sheen of the glaze not conceded to have originated in Ireland but in the Goss factory at Stoke-on-Trent. Most of the early models were marine inspiration. Ambitious designs in basket weave followed. The mark adopted was a tower combined with a greyhound, harp, and shamrock with the word Belleek. An American Belleek used the crown and sword with the name; also a crescent and Trenton, N. J. Illus. E.B.H.

Cartel of chinaware manufacturers formed in Germany. DOUGLAS MILLER. *Commerce Repts.*, **43**, 217 (1929).—Negotiations between the leading German manufacturers of china tableware to curtail production and to raise sales prices have come to a successful end. The manufacturers involved in this program control about 80% of Germany's production capacity of tableware. Production is to be curtailed to an extent that overproduction resulting in price-cutting competition will be avoided entirely. Only such quantities of tableware will be manufactured in the future as the market can readily absorb. The quality of the products is to be improved, and the prices are to be raised about 10%. It is hinted that an agreement will be reached shortly with the Czechoslovakian chinaware industry, based on the subject of curtailing production and increasing prices. As Germany and Czechoslovakia rank among the most important manufacturers and exporters of china tableware in Europe, such an agreement would be of great importance. E.J.V.

High-voltage porcelain pulley for dead-ending cables. ANON. *Bull. Can. Inst. Mining Met.*, **210**, 1133 (1929).—A new device providing ample bending radius for the conductor, and useful for the smaller size of copper and aluminum cables in rural electrification. H.H.S.

Stellmacher-porcelain. HERTWIG-MÖHRENBACH. *Sprechsaal*, **62** [39], 714–15 (1929).—Stellmacher was a pioneer in the manufacture of high-grade artistic china in Teplitz. His work is briefly reviewed and the formulas of his bodies and glazes are given. Illustrated. T.W.G.

Advanced casting process. ANON. *Ceram. Ind.*, **13** [5], 468 (1929).—New method of manufacturing dinnerware has been developed by Marc Solon and William Glover, which was pronounced as a decided advance in dinnerware manufacture. By its use the output of every sagger is said to be increased anywhere from 100 to 500%, and the economy in these items may well be appreciated by any pottery manufacturer. The explanation of this achievement is that the physical structure of the clay in every piece made by this new casting method is absolutely uniform, and the absence of warping in the fire is a distinct advantage. The plates are made without any foot, so that they nest upon each other as closely as is possible. By the new casting method pieces of any shape can be made as rapidly as the simplest forms. Delicately modeled embossment can be produced with great accuracy. F.P.H.

Chinaware company to expand. ANON. *Clay-Worker*, **92** [4], 287 (1929).—The Crooksville China Co., Crooksville, Ohio, manufacturers of general ware, has authorized plans for a new addition to its pottery, to be one story, 70 by 145 ft., and will begin superstructure at an early date. A new decorating kiln and auxiliary equipment will be installed. The expansion is reported to cost close to $50,000, with machinery. E.J.V.

Potteries in Burton-on-Trent district. ANON. *Pottery Gaz.*, **54** [629], 1767–71 (1929).—At Church Gresley, in Derbyshire, the T. G. Green and Co., Ltd., has two important potteries, the "Old" and "New," employing some 700 workers. The two plants are described. Photographs of both plants and sections are presented. E.J.V.

PATENTS

Insulator. RICHARD H. MARVIN. U. S. 1,733,067, Oct. 22, 1929. An insulator having a head portion comprising a side wall, and an integral end diaphragm connected thereto by a substantially 90° bend, the head portion being provided with a conductor-receiving groove, in combination with a cap supported by the insulator and surrounding but out of contact with the bend to stabilize the temperature of the insulator head in the area of the bend, the cap having means through which the conductor may pass.

Casting link-type insulators. MINOR F. H. GOUVERNEUR AND FRANK J. STEVENS. U. S. 1,733,729, Oct. 29, 1929. Method of making a link insulator, consisting in forming a porous tubular core element having spaced arms connected by a curved bight portion, and molding an insulator body about the core, the core element having its ends projecting beyond the body and open to serve as a drying flue.

Suspension insulator fitting. HENRY R. HOLMES. U. S. 1,734,167, Nov. 5, 1929. (1) Suspension insulator comprising a plurality of insulator units, an upper and a lower arcuate way for a U-link in each unit, a U-link passing through each arcuate way, and suspension fittings for connecting certain of the U-links of adjacent insulators, the fittings being so shaped as to conform to the contour of the insulator units and to inclose portions of the U-links and their arcuate ways. (2) In a suspension insulator, U-links, an insulator unit having upper and lower arcuate ways adapted to receive the U-links, in combination with a coupling device having upper and lower connecting means adapted to hold the legs of U-links, the device comprising integral apron-like extensions adjacent its ends adapted to overlie portions of the U-link between the coupling and the insulator to shield the link against play of an arc thereon.

Insulator for withstanding fog conditions. ARTHUR O. AUSTIN. U. S. 1,735,560, Nov. 12, 1929. (1) Combination with an insulator for high potential transmission lines of means for heating the insulator to dispel the moisture therefrom, the heating means comprising a resistance path for current of a width less than the periphery of the insulator and consisting of porous material. (2) An insulator having a plurality of parts and a high-resistance leakage path extending over the surface of the parts from one terminal of the insulator to the other, the nature of the path being different in width and

direction for the different parts. (3) Combination with an insulator for high potentials, of means for heating the insulator to prevent undue accumulation of moisture thereon, the heating means automatically operating to increase the amount of heat delivered to the insulator when the amount of moisture present is increased. (4) Combination with an insulator for high potential transmission lines, of means for delivering heat to the insulator to dispel moisture therefrom, the heat-delivering means comprising a resistance member which has its conductivity affected by moisture.

Teapot. JAMES HENRY THOMPSON. U. S. 1,736,381, Nov. 19, 1929. In teapots, an infusion chamber having a circular flange at the upper end and being rotatably and detachably dependent from the mouth flange of the teapot, the chamber having a finely perforated wall and proceeding downwardly with a gradual variation of the form to a non-circular section, with a closed bottom at the lower end of the chamber.

Insulator. JESSE E. MATEER. U. S. 1,736,455, Nov. 19, 1929. An insulator comprising a hollow dielectric body of inverted substantially frustoconical shape having an inwardly offset wall closing its upper end, cylindrical ends and a plurality of downwardly-and-outwardly sloping annular side flanges of downwardly successively decreasing diameters and increasing extent from the body, an upper ring terminal having portions for mounting the insulator by turning the same, and a lower terminal having a cylindrical portion secured to the body, an apertured transverse end wall and laterally-extending conductor-mounting portions.

Ceramic products. J. W. MELLOR AND CERAMIC PATENT HOLDINGS, LTD. Brit. 318,188, Oct. 23, 1929. White pottery, tile, and ceramic products are prepared by mixing intimately 2 to 4% or more of a bleaching agent consisting of alumina, or a mixture or compound of alumina and an alkaline earth with the normal body, especially in the process described in Brit. 253,184 (see *Ceram. Abs.*, **6** [10], 453 (1927)) or Brit. 302,519 (see *Ceram. Abs.*, **8** [5], 318 (1929)) and firing at a comparatively low temperature. Magnesia may replace the alkaline earth. China clays or cornish stone may be thus improved for pottery making.

Molding ceramic articles. INTERNATIONAL GENERAL ELECTRIC CO., INC. Brit. 318,866, Nov. 6, 1929. In molding objects of porcelain, earthenware, etc., the upper die is arrested within a small distance of the lower die to provide for escape of superfluous material, and, after molding, the upper die is first slowly raised together with the bottom ejector which, after a predetermined distance, drops automatically leaving the article adhering to the upper die, the latter being then moved more rapidly and the article detached just before the end of the upward movement.

Equipment and Apparatus

X-ray testing winning favor. EDITORIAL. *Iron Trade Rev.*, **85**, 986 (1929).—Dangers of X-ray work have been largely surmounted, and hundreds of young engineers are turning to X-ray manipulation. The advantages of the X-ray test for internal defects are (1) saving of time and (2) nondestruction, but at present the thickness of a steel casting that can be X-rayed is only 3 in. H.H.S.

Mercury displacement volumeter. COLIN G. JACKSON. *Jour. Sci. Instruments*, **6**, 261–62 (1929). (*C.A.*)

New integrating microphotometer for X-ray crystal reflections. I, II. W. T. ASTBURY. *Jour. Sci. Instruments*, **6**, 192–96, 209–13 (1929). (*C.A.*)

Advanced methods of installing CO_2 meters. ANON. *Iron Age*, **124** [3], 164 (1929).—Principle, construction, and method of installation of latest Brown CO_2 meter are discussed. E.C.C.

New plastometer. E. KARRER. *Ind. Eng. Chem., Anal. Ed.*, **1** [3], 158–60 (1929); for abstract see *Ceram. Abs.*, **8** [12], 903 (1929). R.G.M.

Optical and radiation pyrometers. ANON. *Brit. Clayworker*, **38** [450], 262 (1929).—Uses and value of these instruments together with a description of them are given. R.A.H.

Small optical pyrometer. ANON. *Brass World*, **25** [10], 244 (1929).—The Maco Template and Engineering Co., Ltd., London, has placed on the market an optical pyrometer of very small size. The instrument is known as the "Pyroversum" and can be carried in the pocket. It registered temperatures from 550 to 1200°C, has as cale $5^1/_2$ in. long, calibrated for every 10°. The makers state that the instrument has received the highest recommendations from European users. E.P.R.

New potentiometer pyrometer recorder. ANON. *Glass Ind.*, **10** [11], 275–76 (1929); *Brick Clay Rec.*, **75** [10], 634 (1929).—A new potentiometer recording pyrometer embodying a number of distinctly new characteristics has been developed by Wilson-Maeulen Co., employing the potentiometer principle with a mechanical simplicity. Details of the new features of the instrument are described. Illus. E.J.V.

Thermo-element repairing. ANON. *Brass World*, **25** [10], 245 (1929).—On examination under the microscope, used thermo-elements show a crystalline structure as well as discoloration. These changes can be reversed by a special reclaiming process and the thermo-element restored to operating condition. While a couple cannot always be restored to its orginal condition, it can be sufficiently improved to make the service profitable to users of thermo-elements. E.P.R.

Question of drying. P. P. BUDNIKOFF AND W. J. ENDOWITZKY. *Sprechsaal*, **62** [39], 711–14 (1929).—Calculations are carried out showing the available heat from firing and the required heat for drying of porcelain in comparison with brick. While in the manufacture of porcelain an excess of heat is available, there is a shortage of heat evidenced in the manufacture of brick. This indicates the necessity of well-constructed tight buildings. T.W.G.

Drying clay goods. G. LAVELLE. *Gas Jour.*, **188** [3463], 39 (1929); see *Ceram. Abs.*, **8** [12], 905 (1929). T.W.G.

Controlled drying for electrical porcelain. ANON. *Ceram. Ind.*, **13** [5], 469–70 (1929).—Manufacturers of high voltage electrical porcelain have found extreme difficulty and uncertainty in bringing their tube stock to a suitable condition for turning to shape on the lathes. The removal of enough moisture to leave the tube stock in a semihard condition with a moisture uniformly distributed through the piece has been the aim. The problem has apparently now been solved satisfactorily by air-conditioning engineers who are thoroughly familiar with humidity drying and with all of the factors of control in temperature, humidity, and air movement. F.P.H.

Separation of iron from ceramic masses. ANON. *Tonind.-Ztg.*, **53** [53], 941–43 (1929).—Various types of equipment used to remove iron from ceramic bodies are described. The equipment is made by the Krupp-Grusonwerk. F.P.H.

Helical press for brick. L. DEVILLER. *Rev. mat. constr. trav. pub.*, No. 241, pp. 220–21B (1929). A.J.M.

Lubrication of silent chain in the ceramic industry. THOMAS K. BROWNE. *Brick Clay Rec.*, **75** [9], 568–69 (1929).—The entire subject of lubrication in the ceramic industry is past the experimental stage as far as the silent chain is affected, and it has been found that a few simple rules will cover the entire field of general use. Six general types of silent chain lubrication are listed and discussed. These include using grease on the inside of the chain, running the bottom of the chain through an oil bath, force feed inside the drive housing, and sight feed and sight control. E.J.V.

Issue catalog. ANON. *Abrasive Ind.*, **10** [11], 34 (1929).—Chain Belt Co., Milwaukee and its subsidiary, the Stearns Conveyer Co., Cleveland, have issued an 815-p. catalog. The first pages are devoted to views of the Chain Belt plant, a discussion of the

advantages of mechanical handling, a list of the industries served by the company, notes on ordering and types and applications of chains and conveyers. The next section discusses engineering features and care of conveyers. Elevators are described and illustrated with line drawings and halftone reproductions in the next section. Bucket carriers, different type conveyers, and water-screening machinery also receive considerable attention. The book is well illustrated with reproductions of photographs of typical installations and drawings showing general assembly features. E.P.R.

Chromium plating textbook. ANON. *Brass World*, **25** [10], 244 (1929).—The volume will cover in detail all the elements entering into successful chromium plating, covering the cleaning and pre-plating operations thoroughly, it is stated. Such subjects as overcoming flaws in nickel, chromium-polishing methods, solutions for copper and other finishes. E.P.R.

Permissible mining equipment. ANON. Bur. Mines, *Information Circ.*, No. 6127, 13 pp. (1929).—The present list includes practically all equipment tested and approved by the Bureau up to and including July 1, 1929. R.A.H.

Clay extraction by means of pneumatic shovel-hammers. ANON. *Tonind.-Ztg.*, **53** [54], 959–61 (1929).—Use of pneumatic shovel-hammers for mining clay is described. F.P.H.

American source of grinding pebbles. GEORGE B. BOWERS. *Rock Prod.*, **32** [21], 68 (1929).—Pebbles have an important place in manufacturing and building throughout the U.S., hence a community with an inexhaustible supply near a railroad and a pavement is a valuable asset. Inexhaustible is used advisedly, meaning a dependable renewal. Such a supply exists on a beach near Encinitas, Calif. F.P.H.

Vibratory screen motion found most efficient. ANON. *Eng. Mining Jour.*, **128** [2], 51 (1929).—Experiments made by A. W. Fahrenwald and S. W. Stockdale for U. S. Bur. Mines, Univ. Idaho, and Idaho Bur. Mines on effect of different types of sieve motion on screen efficiency of crushed and sized white quartz and galena sand from 14 to 20 to 65 to 100 mesh. Tyler sieves of fourth root of two ratio were used. The order of screening efficiency from high to low was (1) high frequency vibratory, (2) horizontal jarring, (3) vertical jarring, (4) horizontal rotary motion with vertical jarring, and (5) horizontal rotary motion without vertical jarring. With the vibratory type, a critical amplitude and frequency of vibration at which maximum screening efficiency is obtained exists for each size and density of sand screened. Amplitude of vibration for maximum screening efficiency is directly proportional to the size of the sand screened. Frequency of vibration for maximum screening efficiency is inversely proportional to the size of sand screened. Rate of screening for thick beds is less than for thin beds. E.C.C.

BOOK

Gages and Fine Measurements. F. H. ROLT. 2 vols. Macmillan & Co., London, 1929. Price 2 guineas.—The first volume deals with standards of length, measuring machines, and comparators; the second, with limit gages, measuring instruments, and general methods of measurement. H.H.S.

PATENTS

Teeth for excavating dippers, etc. WALTER E. MILEY. U. S. 1,736,045, Nov. 19, 1929. In an excavating dipper, a plurality of teeth each comprising a base secured to the front of the dipper and a point detachably secured to the base, and parts carried by the points of the teeth and arranged wholly between the teeth and in advance of the dipper front to protect the latter from wear.

Feeding and metering pulverulent material. ERVIN G. BAILEY. U. S. 1,736,243, Nov. 19, 1929. Apparatus for feeding pulverized material, comprising a bin or reservoir for the material to be fed; a preparing appliance located below the same, comprising a

number of pockets, and an apertured cover plate between the pockets and the supply reservoir, which covers a portion of the pockets and leaves the others in communication through the aperture with the reservoir, and a similar apertured plate below the pockets, covering the lower ends of the pockets where uncovered by the upper plate and leaving the lower ends uncovered where covered by the upper plate; means for producing a relative movement of the pockets and the cover plates whereby the pockets are alternately uncovered at top while covered below and vice versa, and an air vent for the pockets in the lower side of the first-named cover plate.

Kilns, Furnaces, Fuels, and Combustion

Tunnel kiln. ANON. *L'Émail*, **1** [9], 39–40 (1929).—The operation of the continuous tunnel kiln as used in Germany and U. S. is described. T.W.G.

Water-cooled tunnel kiln. ANON. *Ceram. Ind.*, **13** [5], 469 (1929).—A most interesting development in tunnel kiln installation is the McDougal tunnel kiln at the Flint Faience and Tile Co., which is used for firing glazed faience and unglazed vitreous tile. The kiln is divided into five zones, *i.e.*, preheating zone, firing zone, indirect air-cooled zone, water-cooled zone, and direct air-cooled zone. The water-cooling zone is 28 ft. long, and consists of coils suspended over the cars and along the side walls through which water is kept circulating to absorb heat from the ware and the cars. The direct air-cooling zone is 18 ft. long. The last two zones are covered with sheet metal to facilitate radiation. At the exit end, air from a blower is introduced through a fan-shaped duct in the metal cover and is forced down on the ware to aid in cooling. F.P.H.

Heat drawn horizontally through new kiln. ANON. *Ceram. Ind.*, **13** [5], 468–69 (1929).—A new type of china kiln was brought to the notice of the pottery industry by the British Ceramic Society. This kiln embodies a new principle of firing, the heat being drawn horizontally across the kiln through perforations in a central stack. This method greatly reduces the period of firing, equalizes the heat in all parts of the kiln, and effects considerable economy in fuel and saggers. One of the new type kilns is installed in a china plant at Stoke-on-Trent, England, is 11 ft. 3 in. in diameter, and holds 525 normal saggers, representing approximately 1300 dozen ware. There are only 4 fire holes, and instead of there being flues under the bottom of the kiln, there is a solid base, with the single exception of a flue which leads to the chimney. There is also a solid crown, except for the cooling damper, which occupies the position of the crown damper in the ordinary beehive kiln. F.P.H.

Long muffle kiln for production of tile stoves. JOSEF PÖLLMANN. *Keram. Rundschau*, **37**, 6–9, 123–25 (1929). H.I.

Mechanical stoking of kilns. JOHN PROCTOR. *Brit. Clayworker*, **38** [450], 247–48 (1929).—P. discusses mechanical stoking of continuous kilns of the Hoffman and Staffordshire type. Pyrometer records of hand firing show a sudden accession of heat during the time of stoking of about 40°C. This increase ceases within 3 mins. of the actual firing and a decrease sets in which continues for 35°C thus giving a gain of 5°C for the stoking before the operation is repeated. A regularly hand-fired kiln thus gives a zigzag slowly rising line of heat indicator. By mechanical stoking the conditions are completely changed. Instead of intermittent and haphazard stoking the feed can be regulated to the requirements of the kiln and its contents. The coal is prepared for its work and combustion is immediate and absolute. The pyrometer record is continuous and regular. The maximum heat is reached as quickly as the goods will bear it and is easily maintained. The saving in firing time is enormous while the production of the kiln is increased. Records show from 100 to 300% increase in production. The same results in fuel saving per 1000 brick were also obtained. Usually the cheapest coal is

used which is screened through 1/8-in. mesh. Details of the methods of feeding the coal to the kilns are given. R.A.H.

How to set a zigzag kiln. ANON. *Brit. Clayworker*, **38** [450], 240–41 (1929).—The Hoffman type of zigzag kiln is characterized by the rapidity of fire travel which with induced draft may attain a speed of 60 ft. in 24 hrs. By reason of transverse walls and arches, the total length of the gallery of a kiln may be as much as 650 ft. instead of the normal length found in the Hoffman kiln of about 250 ft. The gallery may be from 6 to 8 ft. wide and 8 ft. high, the width more particularly being regulated according to the type of goods to be fired. The heating zone may be about 125 ft., the firing zone 80 ft. and the cooling zone 250 ft. The zigzag kiln is acknowledged to be more economical than any other type. By reason of the serpentine shape of the gallery the fire travels by a tortuous path and changes direction completely. Four figures are given showing how the goods should be placed in the kiln to obtain best results in firing. R.A.H.

Drainage of kiln bottoms. ANON. *Rev. mat. constr. trav. pub.*, No. 241, pp. 209–11B (1929).—Proper construction of kiln bottoms is shown and explained. A.J.M.

Starting the firing of a continuous kiln. J. WELTER. *Rev. mat. constr. trav. pub.*, No. 241, pp. 205–209B (1929).—Detailed instructions are given for lighting a continuous kiln. A.J.M.

Special brick linings. ANON. *Brit. Clayworker*, **38** [450], 231 (1929).—Kilns for firing common brick are often lined with ordinary building brick but the practice is not a good one unless the brick employed are of a semi-refractory material. Most kilns especially those used for facing brick should be lined with fire brick. A chemical analysis of brick for lining kilns is seldom needed and is often liable to be misleading. Fireclay brick and grog brick are usually preferable to silica brick as they are less liable to spall. The refractoriness of brick for lining kilns need not usually be very high, but should not be less than cone 28. Brick for the ovens used for hard porcelain are required to be more refractory and should have a high refractoriness under load. Resistance to slag and other corrosive influence need not usually be very great. Highly siliceous brick are not very suitable for frit kilns, grog, or aluminous brick with a smooth surface being best for this purpose. The surface of the brick may be covered with powdered china clay which fills the pores and protects the brick. Some users claim that finely-ground zirconia is even more preferable for this purpose. Brick used in kiln linings must be well fired to avoid after-shrinkage. Fireclay mortar should be used in laying the brick and thin joints should be used. Gas-fired kilns usually require brick of greater refractoriness than coal-fired kilns as there is a tendency to develop higher local temperatures. R.A.H.

Diffusion flames. S. P. BURKE AND T. E. W. SCHUMANN. *Ind. Eng. Chem.*, **20** [10], 998–1004 (1928).—Flames may be divided into two classes: (1) flames of the Bunsen burner type in which the combustible gas and air are premixed before ignition occurs and (2) flames in which the combustible gas and air meet coincidentally with the occurrence of combustion. To this second class of flames the authors have applied the term "diffusion flames." An analysis of this type of flame was made which has led to a theory of its mechanism. A mathematical presentation of the theory is given and also the results of an extensive experimental investigation of the deductions therefrom. Considerable data have been secured concerning the physical characteristics, mechanism and general properties of this common type of flame. A series of photographs are included showing the results of variation in the factors affecting this type of flame. R.G.M.

Measurement of temperatures of stationary flames. A. G. LOOMIS AND G. PERROTT. *Ind. Eng. Chem.*, **20** [10], 1004–1008 (1928).—The concept of temperature as applied to flames is discussed. A number of proposed methods for measuring the temperature of flames are critically reviewed and the optical method of Kurlbaum-Fery is described and

examined in detail. This method depends upon comparing the brightness temperature of a continuous radiator with the brightness of the radiation from the flame colored with an alkali-metal vapor at a given spectral line. From a consideration of the laws of radiation it is shown that the true flame temperature is equal to the brightness temperature of the comparison radiator as read with an optical pyrometer, when the spectral line is just reversed as seen in a spectrometer. Curves representing flame temperature as a function of air-gas ratio as measured by the line-reversal method are given for Pittsburgh natural gas, methane, propane, and carbon monoxide. These results are compared with measurements depending on the flame gases heating a solid radiator contained in the flame and with the calculated results for the maximum temperature attainable at complete combustion. R.G.M.

Thermal decomposition of ethane, ethylene, propane, and propylene. F. E. FREY AND D. F. SMITH. *Ind. Eng. Chem.*, **20** [9], 948–51 (1928).—This is a report of an investigation to determine types of reaction, nature of the products, and their relative predominance in the thermal decomposition of the simpler hydrocarbons. The effect of certain catalysts was investigated, but most of the reactions took place in silica containers which exerted very little catalytic effect, and involved only gaseous products. R.G.M.

Handy charts for power plant. W. F. SCHAPHORST. *Blast Fur. Steel Plant*, **17** [10], 1531–32 (1929).—Comparison of costs in firing with coal and fuel oil is discussed. Height and area of chimneys with reference to draft for a given rate of burning is considered. F.P.H.

Fuel research laboratories at Ottawa, and scope of their investigations. B. F. HAANEL. *Bull. Can. Inst. Mining Met.*, **210**, 1197–1214 (1929).—An account by the chief engineer of the laboratories. H.H.S.

Coal and coal cleaning. R. H. ALLEN. *Mech. World*, **86** [2235], 415 (1929).—In a paper entitled "Coal and Coal Cleaning" recently read before the Junior Institution of Engineers, A. dealt with the advantages and methods of reducing as far as possible the ash-forming material present in coal before its use as a fuel. E.P.R.

Combustibles and their combustion. I. ROGER MARTIN. *Chaleur ind.*, **10**, 85–95 (1929).—Combustion calculations are given. By means of monographic charts the calculations are simplified. The charts include: (1) relation between the heating value (high or gross) and the per cent carbon, (2) relation between per cent hydrogen and heating value, (3) relation between raw and corrected (free from ash and water) combustible, and (4) carbon and heat in the cinders. **II.** *Ibid.*, **10**, 149–54.—Calculations are continued. The charts given are (1) heat in the combustion gases, and (2) heat required to raise the combustion gases to a given temperature. **III.** *Ibid.*, **10**, 206–12.—The calculations are continued. Charts are given for (1) determination of the coefficient of loss, (2) volume and composition of gaseous products from 1 kg. of combustible. A.J.M.

Official test of Maclaurin process of low-temperature carbonization by Fuel Research Board. DAVID BROWNLIE. *Gas Age-Rec.*, **64** [10], 303–304 (1929).—The Maclaurin process consists in the use of a vertical retort of great height, approximately 45 ft. in the standard design, corresponding to a load of 20 T. of average bituminous coal per 24 hrs., the cross-sectional area being comparatively small; in general the appearance of the setting somewhat resembles a small blast furnace. For the production of a hard, smokeless, free-burning fuel, now known as "Kincole," a portion of the charge is withdrawn from the bottom of the retort every hour, and a corresponding amount of raw coal admitted at the top. The partial gasification is given by an air blast admitted through portholes near the bottom of the setting, together with about 400 to 500 lbs. of steam per ton of coal passed into the bottom of the fuel discharge portion, while the whole of the

mixed gases and vapors formed by gasification and low-temperature carbonization are taken from the top of the setting. F.P.H.

Mode of calculation for high free-standing chimneys. MAX BULNHEIM. *Tonind.-Ztg.*, **53** [57], 1016–17 (1929). F.P.H.

Design and operation of gas-heated furnaces. C. M. WALTER. *Chem. and Ind.*, **48**, 954–61 (1929).—The ever-increasing use of gas as fuel has resulted in many excellent designs of furnaces. W. deals in detail with the working chamber, the producer, the regenerator, and recuperator. Heat balances are discussed. (See *Ceram. Abs.*, **8** [7], 523 (1929).) H.H.S.

Gas producer developments. G. W. GALE. *Ceram. Ind.*, **13** [5], 479–80 (1929).—Steam is required in a producer to keep the temperature below the fusing point of the ash to prevent clinkering. The steam requirement is directly a function of the nature of the coal used. Any excess of steam above this requirement causes a further quenching action which lowers the furnace temperature below that indicated by the fusing point of the ash. This results in a high hydrogen content and decreased producer efficiency, due to lowering the ratio of carbon monoxide to carbon dioxide since high temperature in the reduction zone of the firebed is necessary for complete and rapid reduction of CO_2 to combustible CO, and for quick decomposition of water vapor. The use of the turbo blower permits operation of the producer at the highest temperature consistent with the clinkering qualities of the ash by means of control of the steam admission, without affecting the air delivery, and thus introduces a method of regulation which is impossible with a steam jet. F.P.H.

PATENTS

Tunnel kiln for firing objects made from carbon-slag. WILHELM HOFFMEYER. Ger. 480,479, June 8, 1927. Details of the circulation of the hot gases are given. (*C.A.*)

Annular or zigzag kiln for firing earthenware. BORNKESSEL & CO. M.B.H. Ger. 481,397, Aug. 11, 1925. Details of construction and arrangement are given. (*C.A.*)

Annular kiln for crucibles. AUGUST HUNECKE. Ger. 481,057, Feb. 12, 1928. Details of removing smoke are given. (*C.A.*)

Continuously-acting melting furnace for glass or metals. RUDOLF SCHNEIDER. Ger. 480,619, Sept. 5, 1924. Details of circulation of hot gases in furnace structure are described. (*C.A.*)

Kiln-bracing construction. GRAFTON E. LUCE. U. S. 1,732,239, Oct. 22, 1929. False side wall for brick kilns comprising pier boxes positioned in the foundation, a plurality of prop posts removably mounted in and supported by the respective pier boxes, a plurality of cross bars supported and carried by the prop posts, and a plurality of supporting carriers having hook portions adapted to hook over the top of the crossbars, the carriers being adapted to support spacing members therein for directly engaging the wall of the kiln and holding it in spaced relation to the props and bars.

Downdraft kiln. MORTIMER JONES. U. S. 1,733,488, Oct. 29, 1929. Kiln for firing and curing earthen products comprising a structure provided with floor, walls, and dome of known type, and having underground tunnels, flues leading to the tunnels, the walls having a series of openings forming ports, a series of inclined diverging flues positioned above the underground flues and communicating with the ports for directing the heat to the dome of the kiln and down through the ware, and means for directing heat from the underground flues to the inclined flues.

Kiln. EDWARD GEORGE SPENCER-CHURCHILL. U. S. 1,734,885, Nov. 5, 1929. A construction or arrangement of kilns for firing brick, tile, and ceramic goods wherein a number of kilns having side bag chimneys through which hot combustion gases from a

furnace pass upwardly and then downwardly through the body and floor of the kiln to an outlet communicating with a system of flues interconnecting the kilns with each other and with a common chimney are arranged in pairs about the common chimney, the members of each pair being separated by a common end wall.

Electric oven. ROBERT H. MACINNES. U. S. 1,736,451, Nov. 19, 1929. An electric heating element comprising a mounting-plate, and supporting-blocks provided with shanks removably and interlockingly connected with the mounting-plate, each of the blocks having a head-portion provided with a pair of laterally open channels extending in one direction and equipped with retainer-lips and having an intersecting channel open at one side.

Furnaces. C. B. WINZER. Brit. 318,650, Oct. 30, 1929. A continuously-operated furnace or kiln comprises a stationary hearth or platform, on which the goods or materials are placed, and a continuously movable or traveling tunnel with furnaces arranged to provide heating and cooling zones. Producer gas is supplied through pipes to combustion chambers arranged on the inner periphery of the tunnel. The goods to be heated are carried on trucks which are passed into the loading and unloading sections of the tunnel over a platform. This platform moves with the tunnel, but can be moved a short distance relatively thereto to allow a newly-charged truck to be brought opposite the loading opening as soon as a fired charge has been withdrawn. The loading and unloading section can be isolated from the remainder of the tunnel by doors.

Geology

Geophysical abstracts. V. FREDERICK W. LEE. Bur. Mines, *Information Circ.*, No. 6175, 21 pp. (1929).—In continuation of previous circulars a series of abstracts are given which were taken from the world's literature on the following methods of geophysical prospecting: gravitational, magnetic, seismic, electrical, radioactive, geothermal, and others. (For preceding abstract see *Ceram. Abs.*, **8** [12], 928 (1929)). R.A.H.

Geological relations of deposits of ceramic raw materials found in Bavarian Upper Palatinate. M. PRIEHÄUSSER. *Keramos*, **8** [18–19], 637–94 (1929). F.P.H.

Roerstrand feldspar and Forshammar feldspar. BERDEL. *Keram. Rundschau*, **37**, 87–92 (1929).—The Ytterby feldspar deposit on the island of Resäron and the deposit at Forshammar, Sweden, are described. The Ytterby deposit is a pegmatite dike of irregular cross-section with an explored depth of 145 m. The hanging wall is diorite, the foot-wall hornblende gneiss. The feldspar requires careful sorting before marketing. The deposit also affords segregations of crystalline quartz which are satisfactory for use in fine ceramics. Two analyses show 0.2% Fe_2O_3 or less, K_2O 12.26 to 12.90%, Na_2O 2.10 to 3.06, and Al_2O_3 19.41 to 19.73. Methods of mining and milling are described. The Forshammar deposit is a graphic granite composed very largely of feldspar and quartz with a little muscovite. Tourmaline and pyrite are absent. The two analyses given show 0.03% Fe_2O_3. Rational analyses show about 66% feldspar, 25.4% quartz, and 8.6% clay substance. Modern methods of mining and milling are employed. H.I.

Fluorspar and cryolite in 1928. HUBERT W. DAVIS. Bur. Mines, *Mineral Resources U.S.*, Part II, 17 pp. (1929).—A brief description of the mineral is given. Shipments of fluorspar to steel plants by domestic producers were 16% more in 1928 than in 1927, and there were increases of 9% and 24% respectively, in the shipments of fluorspar to manufacturers of glass and enamel. Shipments of fluorspar for use in the manufacture of Portland cement amounted to 951 short tons in 1928, and though small in comparison with shipments for other uses represent substantial increases over corresponding

figures for 1927 and 1926. In 1928 shipments of fluorspar from domestic mines aggregated 140,490 short tons, valued at $2,656,554, an increase of 25% in quantity and 31% in total value as compared with 1927. The retort also discusses production in 1928 by states, stocks at mines or shipping points, imports and exports, uses, consumption, world production, and a section on cryolite. R.A.H.

Zinc in 1927. ELMER W. PEHRSON. Bur. Mines, *Mineral Resources U.S.*, Part I, 28 pp. (1929).—Production of primary zinc in the U.S. in 1927 amounted to 592,516 short tons, a decrease of 4.2% from 1926; production from domestic ores declined 5.7% whereas production of foreign ores increased. Domestic consumption dropped 7%. R.A.H.

Rare metals: cobalt, molybdenum, nickel, tantalum, titanium, tungsten, radium, uranium, and vanadium in 1927. FRANK L. HESS. Bur. Mines, *Mineral Resources U.S.*, Part I, 60 pp. (1929).—The report discusses both the domestic and world production of these minerals. R.A.H.

Tripoli. II. P. B. BUTLER. *Refrac. Jour.*, **5** [49], 14–16 (1929).—Three standard colors are produced, rose, cream, and white, and due to the mixed colors hand-sorting is unavoidable, both in the quarries and in the drying sheds, although there is a growing demand for "mill run" material in which no attention is given to color. Three standard grades of fineness are recognized: "one ground," the coarsest, which is all through a 30- to 40-mesh screen, and contains about 85% that is finer than 200-mesh; "double ground," the medium grade, all through 110 mesh, of which some 96% will pass a 200-mesh; and "air float," which is the air-floated dust, all of which is finer than 200-mesh and about 99.5% finer than 325. At the present time the largest part of the production, about 60%, is used in the manufacture of foundry parting, for which it is peculiarly adapted on account of its physical characteristics of bulk, porosity, absorption, and, possibly, its adsorption. The lighter colors are preferred for this purpose. Its porosity allows it to take up the fats, waxes, and oils with which it is mixed, and the particle is permeated with these instead of being coated, as would be the case with a hard, non-absorbent material. The second largest use is in the manufacture of tripoli buffing compositions, which takes about 30% of the production, 5000 to 6000 T. annually in this country and abroad. Its high porosity and absorption makes it possible for tripoli to form a very strong bond with the stearic acid, tallow, paraffin, petrolatum, etc., with which it is mixed, because the particles become well impregnated with these. The most important characteristic, however, is that brought out by C. L. Buchanan, that "tripoli must be sufficiently fine, and the stone from which it is crushed, of a degree of hardness that will permit the completion of crushing or abrasion to the end that the first cut is truly coarser than the succeeding ones." In other words, the true tripoli particle continues to break down under relatively slight pressure until it becomes an impalpable powder. This is due to its fibrous structure and its porosity, and explains why the harder varieties of silica are not satisfactory for this purpose. Filter stones are of three classes, known as "siphon," "gravity," and "pressure." The first is a complete filter in itself; it is placed in a pail or other container with the water to be filtered, the water passes through the stone and siphons out through a rubber tube. The second is generally a tripoli disk, although stones resembling the siphon type are also used. The third is the style of stone used in the metal containers which are attached to the water system. These stones, with proper care, last indefinitely and are easily kept clean by rubbing with a stiff brush in water, which frees the surface of any accumulated silt or other material. In the preparation of filters, choice blocks of stone are sawed into square blocks of proper size, then dried and turned down to the proper size and style on large silicon carbide-coated wheels. Two preliminary tests are in use: First the material is tested between the teeth to determine the texture; any hard particles are quickly noticed.

If this test is satisfactory, the substance is examined with a high-power microscope using polarized light, a purple and green color screen and crossed nicols; this identifies the tripoli particle, as its double refraction is distinctive; 430-diameter magnification is generally used. For Part I see *Ceram. Abs.*, **8** [12], 961 (1929). E.P.R.

Oklahoma glass sand plant. ANON. *Glass Ind.*, **10** [11], 277–78 (1929).—The plant of the Randolph Silica Products Co., Randolph, Oklahoma, is situated where a cross-section of the sand beds shows: glass sand 25 ft.; clay 20 ft.; glass sand 40 ft.; white plastic refractory clay 45 ft.; glass sand 25 ft.; blue plastic refractory clay. Drillings have shown that about 200 acres are underlaid by these formations so it may be seen that the deposit is practically inexhaustible. The upper 25 feet contain over 6,000,000 T. of glass sand. Samples of the sand show from 98.73 to 99.43% SiO_2 and from 0.05 to 0.09% Fe_2O_3. Screen analyses show this sand to be considerably coarser than any now produced in the state. The sand is washed out of the bank hydraulically, thus saving pit labor. A detailed description of the equipment and process used in preparation of the sand for the industry is given. Various views of the plant are shown in photographs. E.J.V.

Economical silica sand plant in New Jersey. ANON. *Rock Prod.*, **32** [22], 59–60 (1929).—The southern part of New Jersey has long been famous for its deposits of silica sand. This sand is used very extensively in making glass, potteries, tile, plaster, stucco, steel and iron molding, cores for foundry work, filter sand, and sandblasting. The varied markets and extensive deposits have been responsible for the large number of plants producing this material and naturally competition is keen between producers. The sand produced is remarkably clean and free from foreign materials such as ilmenite, mica, magnetite, and other oxides of iron such as are found in some deposits. The finished product is all –28-mesh and analyzes 99.5 to 99.75% silica. F.P.H.

Red and green colors of clays and clay-bearing sediments. H. STREMME. *Neues Jahrb. Mineral. Geol.* A, Beil-Bd., **57**, 895–920 (1928).—The color of clays and clay-bearing sediments is a function of the ratio of Fe_2O_3 to FeO. Those sediments with a high ratio have red color. (*C.A.*)

Geology of the ball clays of South Devon. A. SCOTT. *Trans. Ceram. Soc.* [Eng.], **28**, 53–61 (1929).—See following abstract. (*C.A.*)

Ball clays. ALEX. SCOTT. *Dept. Sci. Ind. Research, Geol. Survey Great Britain*, **31**, 68 pp. (1929).—The origin, occurrence, mineralogy, chemistry, physical properties, and utilization of the ball clays of southwest England are discussed. See preceding abstract. (*C.A.*)

Bauxite deposits of Mississippi. PAUL FRANKLIN MORSE. Miss. State Geol. Surv., *Bull.*, No. 19. Reviewed in *Rock Prod.*, **32** [22], 104 (1929).—Known bauxite deposits in the U.S. are confined to the south in the states of Ark., Tenn., Ga., Ala., and Miss. Many of the deposits are impure for use as mined, and bauxite users are viewing with some apprehension the gradual depletion of the high-grade ores. The conviction is gradually taking root that operators must soon resort to one of several alternatives, either importations must be increased, new deposits of high-grade ores must be uncovered, or methods must be developed for removing impurities, thus raising the grade of the abundant low-grade ores. The latter alternative bears considerable promise, and the urgency of the demand for experimental work has led the Southern Station of the U. S. Bureau of Mines at Tuscaloosa, Ala., to undertake tests and studies having in view the development of successful methods of treating the low-grade ores. F.P.H.

So-called kaolinization of granite under humus cover in Black Forest. E. BLANCK AND H. KEESE. *Chem. Erde*, **4**, 33–41 (1928).—Analyses of bleached granite show an increase in SiO_2 and diminution of Al_2O_3 and alkalis. Kaolin is not formed from feldspar under such conditions. (*C.A.*)

Climatic conditions for formation of German kaolin and bauxite. FRITZ KERNER-MARILAUN. *Sitzb. Akad. Wiss. Wien*, Abt. I, **137**, 563–94 (1928).—The variation in temperature throughout the year has been studied for the German kaolin and bauxite areas. The probable temperatures during Eocene, Miocene, and Pliocene time are calculated from indirect paleontological evidence. These studies indicate the probable conditions under which kaolinization of the German rocks occurred. (*C.A.*)

Nephelite. N. I. VLODAVETZ. *Z. prakt. Geol.*, **37**, 10–13 (1929); *Mineralog. Abs.*, **4**, 78 (1929).—Nephelite sand occurs in large quantities on the shores of Lake Imandra, Kola Peninsula, close to a railway. Trials have been made on using it instead of Na_2SO_4 in making bottle-glass. Chemical analyses are quoted and references given to the Russian literature. (*C.A.*)

Mineral raw materials. Survey of commerce and sources in major industrial countries. ANON. Bur. of Foreign and Domestic Commerce, *Trade Promotion Series*, **76**, 278 pp. (1929). (*C.A.*)

North Carolina's mining and quarrying industries most active in state's history. Part I. Nonmetallic minerals. H. J. BRYSON. *Mfrs. Rec.*, **96** [20], 68–70 (1929).—Probably no other state has a greater variety of brick and tile clays and shales than N. C. There are four types of materials found here which are suitable for heavy clay products: the pre-Cambrian shales of Montgomery, Stanley, and Union counties; the Triassic shales of Chatham, Lee, Moore, Rockingham, and Stokes counties; the sedimentary clays distributed throughout the state; and the sedimentary kaolins of Henderson and Buncombe counties. From these clays and shales several types of common and flashed face and buff face brick are manufactured. Cyanite has been found in many localities in the state, occurring in small lens-shaped masses of high-grade material and in schists, the latter offering far greater commercial possibilities. E.P.R.

Deposits of clay discovered. ANON. *Clay-Worker*, **92** [4], 304–305 (1929).—Large deposits of clay have been discovered adjacent to and in the Turner Valley of Alberta and the Government has appointed a board to investigate the possibility of their utilization. E.J.V.

BOOKS

Tin: Its Mining, Production, Technology, and Applications. C. L. MANTELL. A. C. S. Monograph No. 51. 353 pp., illus. Chemical Catalog Co., New York, 1929. $7.00. H.H.S.

Laboratory Investigation of Ores. ERNEST E. FAIRBANKS. Reviewed in *Amer. Mineralogist*, **14** [10], 385 (1929); for abstract see *Ceram. Abs.*, **8** [8], 609 (1929). F.P.H.

Disrupted Strata: Faulting and Its Allied Problems. M. H. HADDOCK. Crosby Lockwood & Son, London, 1929. Price 16s.—A study from the standpoint of the mine surveyor and stratigraphist. H.H.S.

Chemistry and Physics

Accurate measurement of high temperatures. W. E. FORSYTHE. *Jour. Amer. Ceram. Soc.*, **12** [12], 780–813 (1929).—The standard temperature scale is defined and methods of realizing it both in laboratory and in factory practice are outlined Methods of measuring temperatures from very low values to the highest obtainable are described. Use of thermocouples, errors encountered in use of both base metal and rare metal thermocouples, and methods used to avoid these errors are discussed. Thermocouples are useful in measuring temperatures up to about 1000 to 1500°C. Beyond the range of thermocouples and sometimes even in this range it is necessary to use some means of

measuring temperature that depends on the energy radiated from the source under consideration. For this class of work the optical pyrometer is recommended as one very good method. Different forms of optical pyrometers are discussed and advantages and disadvantages of these types are pointed out. The conclusion is reached that for many types of work the disappearing-filament type of optical pyrometer has certain advantages over other forms. Some of these advantages are pointed out and reasons given for the selection of this pyrometer. The necessity for the use of a monochromatic screen with a pyrometer is discussed and a list of the various screens available are given. Reasons are given for the general choice of a red screen for this work. In the use of an optical pyrometer it is at times necessary to know something concerning the wave-length of the light used. This brings up the question of the effective wave-length of the screen used. The effective wave-length is defined and methods given for determining and using this effective wave-length in optical pyrometry. It is shown that with a well-calibrated screen just as definite results can be obtained as with a spectrometer for determining wave-length and the advantages of the screen over the spectrometer are set forth. Methods of calibrating optical pyrometers are discussed which bring in the idea of a black body. Methods of realizing the theoretical black body are given together with some experimental results along this line. The use of absorbing screens in extending the scale of an optical pyrometer is outlined and methods are given of obtaining the transmission of the absorbing screens so that it is easy to calculate the extension of the temperature scale with a particular screen. The kind of an absorbing screen needed for this work is shown and the advantages and disadvantages of the absorbing screens are given. Accuracy tests are included in which it is shown that very good agreement can be obtained in the use of a disappearing-filament optical pyrometer by untrained or slightly trained observers. Results are also given to show what accuracy may be expected from experienced observers from this form of pyrometer.

Volumetric determination of alkali fluorides and silicic acids. W. SIEGEL. *Z. angew. Chem.*, **42** [34], 856–57 (1929).—The method is based on the reaction: $6NaF + SiO_2 + 4HCl = Na_2SiF_6 + NaCl + 2H_2O$. Results agree to within $\pm$ ½% of those obtained by ordinary gravimetric methods. It cannot be used in the presence of any other metallic salts than those of Na, K, or NH_4. L.T.B.

New indicators. R. FRESENIUS. *Z. angew. Chem.*, **42** [36], 892–95 (1929).—A review containing a list of indicators for titration purposes which have been developed within the past few years. They may be divided into several classes: (1) those showing several color changes or over a range of p_H; (2) those which show one color change; (3) those for use in colored solutions; (4) those which depend on the formation of a colloidal flocculate at a definite p_H. L.T.B.

Detection of alkalis in salt mixtures and in silicates. N. A. TANANAEFF. *Z. anorg. allgem. chem.*, **180** [1], 75–82 (1929).—The method described is for the detection of alkalis in the presence of any other element. It depends on the conversion of the alkalis to carbonate by treatment with oxalic acid and subsequent carbonation. Potassium is then detected by the use of a solution of $CoNO_3$, $PbNO_3$, and $NaNO_2$ in the presence of acetic acid; sodium is detected by a solution of $K_2H_2Sb_2O_7$. The advantages of the method are as follows: (1) other cations need not be removed by precipitation with H_2S; (2) no difficultly-washed precipitates are obtained; (3) it is very sensitive; *e.g.*, 0.2% alkali can be detected in kaolin; (4) it is rapid; less than 30 min. are required. L.T.B.

Analysis of clays by microscope. H. MÖHL. *Sprechsaal*, **62** [40], 731–34; [41], 749–52 (1929).—Illustrations of various magnifications up to 500 are used. The existence of secondary and primary particles and their relationship influence the properties of clays. Humus is found with primary and secondary clays though it cannot geo-

logically be fully explained. The following forms of clay substance were found: almost amorphous loosely balled material, flakes, and needles with a refractive index easily determined, and insoluble balls of different tightly packed particles within a surrounding of colloidal material being mostly kaolinic. Silica is embedded in varying forms. The better known European kaolins are investigated and results described. The microscope was useful in determining plasticity and bonding power. Surface luster of clay was found not to be due to the flaky structure but to great fineness and plasticity. The finer the grain of the crystalline particles the greater the bonding power. Klingenberg clay known for its plasticity and bonding power showed extremely small amorphous particles tightly packed with very fine silica nesting. A fired specimen displayed the permanence of kaolinite flakes and the fusion of the colloidal particles. (See also *Ceram Abs.*, **8** [9], 684 (1929).) T.W.G.

Determination of fluorine and of silica in glasses and enamels containing fluorine. J. I. HOFFMAN AND G. E. F. LUNDELL. Bur. Stand., *Jour. Research*, **3** [4], 581–95 (1929).—Various methods of determining silica in the presence of fluorine have been tested but only the procedure developed by Berzelius or some modification was found to be reliable. In the methods described the procedure of Berzelius is modified so as to eliminate (1) the long precipitation period with ammonium carbonate and the difficult filtration which follows, and (2) the slow and troublesome neutralization with small portions of nitric acid. It was found that for quantities of fluorine between 0.01 and 0.10 g. the precipitation of fluorine as lead chlorofluoride is much more convenient and rapid and as accurate as the precipitation of a mixture of calcium fluoride and calcium carbonate followed by extraction of the latter with acetic acid. The lead chlorofluoride method succeeds in the presence of moderate quantities of ammonium nitrate, and boric, chromic, sulphuric, or phosphoric acids; as now written, it is not suitable for determining fluorine in phosphate rock. The presence of much magnesium tends to yield slightly low results. The effects of various other contaminants, such as oxides of tin, antimony, iron, aluminum, nickel, cobalt, manganese, and lead, are shown, and a routine method for determining fluorine is given. R.A.H.

Chemical changes in clay and clay-lime mixtures on firing. C. J. FRANKFORTER AND J. N. DETRICK. *Jour. Amer. Ceram. Soc.*, **12** [12], 771–79 (1929).—Results of experiments indicate that lime added to a clay, of the type studied here, combined chemically with certain of the various constituents of the clay when the mixture was fired at 1000°C. There is also an indication on reactions between iron oxide and silica. The exact nature and extent of these several possible reactions cannot be determined from the data of this limited experimental work. It would be of great value for work of this kind if more information were available relative to the chemical action of various reagents upon the several constituents of clay. Obviously it would be necessary to use pure substances representing these constituents rather than any mixture of them. Work was undertaken to obtain indication of the chemical changes which occur on firing a low lime clay and the same clay with calcium-carbonate additions.

Production of magnesia from dolomite. C. R. PLATZMANN. *Rock Prod.*, **32** [21], 75–77 (1929).—By treatment with CO_2 and KHCO burned dolomite is split up into its constituent parts in such a manner that carbonate of lime is precipitated and $MgCO_3$ $KHCO_3 \times H_2O$ enters in solution. Upon heating the resulting solution to 100°C elimination of $MgCO_3$ $3H_2O$ sets in, from which MgO can be obtained by calcining. The final product obtained is a nearly chemically pure magnesia. The lime residue can be utilized as fertilizer lime. The $KHCO_3$ solution goes back in the process. F.P.H.

Rational (proximate) analysis of refractory clays by decomposition with sulphuric acid. HUBERT GREWE. *Arch. Eisenhüttenwesen*, **3**, 43–48 (1929).—The disagreements in the results of various methods for the proximate analysis of clay are caused

principally by (1) the attacking of other constituents in the clay besides the clay substance, by the H_2SO_4 decomposition, and (2) the residue of the decomposition not consisting entirely of $KAlSi_3O_8$ and quartz. A method giving satisfactory results is developed: In a porcelain dish (1000 cc.) are digested (5 min.) 1 g. clay (dried at 115°) 100 cc. H_2O and 5 cc. KOH (1:2); the mixture is boiled (15 min.) and 100 cc. H_2O added. After cooling, 10 cc. H_2SO_4 (1.84) and 10 cc. HNO_3 are added. After heating $1^1/_4$ hrs. to 140° and holding $1^3/_4$ hrs. here, the temperature is gradually (25 min.) raised to 320° and held here 35 min. After cooling, 600 cc. H_2O is added, the mixture settled 2 hrs. the clear solution decanted off; to the residue 10 cc. HCl (1.19) and 50 cc. H_2O are added, the residue is heated on a H_2O bath (15 min.), filtered, washed with H_2O 3 times, the HCl treatment repeated until the weak green of the acid has disappeared. The residue is then washed into the dish, the volume brought to 250 cc. with hot H_2O and 25 g. crystalline Na_2CO_3 (9 g. of calcined) is added. The mixture is heated on a H_2O bath (2 min.), 5 cc. KOH (1:2) added, the mixture heated (2 min.) again, filtered and the Na_2CO_3–KOH treatment repeated 3 times; the final residue on the filter is washed with H_2O containing 5% alcohol, ignited in a Pt crucible and weighed. The difference between the initial and final weights is the weight of clay. The ignited residue is decomposed by fusing with Na_2CO_3 and K_2CO_3, the melt dissolved in dilute HCl, NH_4OH added in slight excess, the precipitated hydroxides filtered off and dissolved in HCl, and the Al_2O_3 precipitated with $(NH_4)_3PO_4$ and $(NH_4)_2S_2O_3$ as $AlPO_4$ from which the $KAlSi_3O_8$ in the original sample is calculated. The quartz is obtained by difference. (*C.A.*)

Immersion melts of high refraction. Tom Barth. *Amer. Mineralogist*, **14** [10], 358–61 (1929).—There have been difficulties in finding good media of high refraction for refractive index determinations with the microscope. Up to an index of about 2.1 good melts of iodine and piperine can be obtained. Above this value melts of selenium and sulphur have been used, and for still higher values melts of selenium and arsenic trisulphide. The halogen compounds of thallium will render good service if used as high refraction immersion media. They are isotropic and very transparent, are easily prepared and melted on an object glass (or better, between two cover glasses) over a low flame. TlCl can be precipitated from a solution of a thallous salt (*e.g.*, Tl_2CO_3) by the addition of a soluble chloride (*e.g.*, KCl). It melts at 426°C between two cover glasses and recrystallizes on cooling to a limpid, thin, continuous sheet consisting of homogeneous, isotropic crystals. Its index of refraction for different wave-lengths is given. TlBr is prepared in the same way as TlCl. It melts at 450°C. It is colorless in thin sheets. Its index of refraction is shown. Mixed crystals of TlBr and TlI, TlBr and TlI form homogeneous mixed crystals in all proportions and these crystals are isotropic and suitable for immersion media. Precautions should be taken in the preparation of these compounds. They are easily obtained by direct precipitation of the mixed crystals by adding a solution of a mixture of KBr and KI (in the desired proportions) to a cold solution of Tl_2CO_3. F.P.H.

State of scientific and technical research in ceramics. Fridrich Lipinski. *Keram. Rundschau*, **36**, 555–58, 576–78 (1928).—Report of an address given before the German Ceramic Society at Dresden, July, 1928. H.I.

Methods for quantitative determination of values characteristic of plastic state in clays and ceramic masses. Willi M. Cohn. *Keram. Rundschau*, **37**, 51–54, 69–72 (1929).—Plasticity cannot be measured by any single type of measurement. At least the following 6 measurements are necessary: (1) limits of existence of plastic state, (2) number and type of solid and liquid phases, (3) workability, (4) strength, (5) ability to "age," and (6) bonding power. Limits of the plastic state are determined by measuring the temperatures and pressures which define the limits within which the particular composition is plastic. The number and type of the solid and liquid phases

are determined by analysis of these phases although in general it is not possible to determine the composition of the ultimate small particles. A number of methods of measuring workability, strength, and bonding power are reviewed. There is much to be done in determining what effect porosity, structure, impurities, and reaction rate of individual phases have on plasticity. H.I.

Quantitative relations of the countercurrent washing process. L. SILBERSTEIN. *Ind. Eng. Chem.*, **20** [9], 899–901 (1928).—S. presents a series of formulas for use in the determination of the various factors involved in the washing of an insoluble solid with maximum efficiency. R.G.M.

Lead in red glaze. A. GRONOVER AND E. WOHNLICH. *Z. Untersuch. Lebensm.*, **57**, 360–63 (1929).—The red glaze of certain culinary ware may contain $PbCrO_4$ and the conditions of extraction of the Pb for the purposes of analysis are discussed. It is recommended that the glaze be well scalded with hot water, $^2/_3$ filled with 4% vinegar and heated on the water bath for 30 min. Ten successive treatments of this type removed approximately the same amount of Pb (about 7 mg.) for each extraction. The Pb was determined by Sudendorf and Penndorf's modification of Winkler's colorimetric method and by the volumetric chromate method. After extraction, a white, water-soluble efflorescence containing carbonate, sulphate, acetate, and Al was observed on the enamel. (*C.A.*)

Mechanical agitator. G. N. QUAM. *Ind. Eng. Chem.*, **20** [9], 908 (1928).—Q. describes a small agitator for use with standard size test tubes where it is desired to secure uniform, readily controlled agitation of a small sample. R.G.M.

New chemical literature. ANON. *Chem. and Ind.*, **48**, 1025–47 (1929).—The Oct. 25 number of this Journal is an Autumn Review number of new books. Thirty-six books are reviewed; an index of books reviewed during the last six months is given; recent and forthcoming books from British and U. S. publishers' lists are announced. H.H.S.

Boundary conditions in physics. R. B. LINDSAY. *Sci. Monthly*, **29**, 465–71 (1929).—Associated with every physical law are found important boundary conditions of both a general and a specific nature, and forming a significant part of the physical meaning of the law as well as of its practical applications. Boundary conditions serve to pick out useful laws. H.H.S.

Low-humidity drying. M. G. W. TOMLINSON. *Heat Piping, Air Conditioning*, **1** [5], 394–95 (1929).—New psychrometric charts have been calculated and vapor pressures for saturated air-water vapor mixtures are given. (*C.A.*)

Richard Zsigmondy obituary. ANON. *Chem. and Ind.*, **48**, 1966 (1929).—Professor of inorganic chemistry at the Univ. of Gottingen, Nobel prize man in 1925, Z. died at the age of 64. He was one of the foremost workers in the field of colloids, and invented (with Siedentopf) the slit ultra-microscope which led to a revival of the old English method of dark-ground illumination. H.H.S.

Colloidal ferric hydroxide free from electrolytes. P. A. THIESSEN AND OTTO KOERNER. *Z. anorg. allgem. chem.*, **180** [1], 115–19 (1929).—Ferric hydroxide obtained from iron salts always contains electrolytes. These electrolytes may be avoided by using materials which give products easily removed. This is the case when ferri-ethylate is decomposed by water. The ferri-ethylate can be obtained very pure. On hydrolysis a ferric oxide hydrosol is obtained easily freed from all electrolytes. L.T.B.

Validity of Stokes' law for non-spherical particles. A. H. M. ANDREASEN. *Kolloid-Z.*, **48**, 175–79 (1929).—The sedimentation of flint particles in water was studied. The apparatus used is described together with the method of removing samples of the material from the settling chamber at definite times. The actual size-frequency distribution data were obtained by use of the microscope and planimeter. From weight data and Stokes' law the values for grain size obtained agree within the limits of error

of measurements with those obtained photomicrographically, thus verifying the assumption that Stokes' law holds for non-spherical particles. (See also *Ceram. Abs.*, **8** [4], 301 (1929).) (*C.A.*)

Effect of some colloidal chemical properties of kaolin of multivalent cations. I. I. SHUKOFF AND M. N. SOKOLOVA. *Kolloid-Z.*, **48,** 71–78 (1929).—The adsorption of $Th(NO_3)_4$ and $FeCl_3$ by kaolin was studied. HNO_3 reduces adsorption of the former and HCl of the latter. Kaolins from different sources do not have the same adsorption power. The adsorption theory for concentrated solutions is not believed to be applicable here, since at the most only 40 to 50 milliequivalents of Th or Fe salt is present. The hydrolytic theory seems to explain the data more accurately. Cataphoretic and electro-endosmotic experiments show a reversal in charge as the concentration increases. The point of reversal is not at the same concentration for the two methods of observing the sign of the charge. The rate of sedimentation of kaolin passes through a minimum for concentration of electrolyte while the rate of filtration passes through a maximum although not at the same concentration of electrolyte. No explanation of this fact could be found. (*C.A.*)

Coagulation and particle size. P. A. THIESSEN, K. L. THATER, AND B. KANDELAKY. *Z. anorg. allgem. Chem.*, **180** [1], 11–18 (1929).—These studies were undertaken to determine the effect of particle size on the stability of colloidal systems by the addition of coagulating electrolytes. It was necessary to obtain a series of such systems whose individual members varied only in particle size. The other properties of the members of the series were identical. It was found that (1) the speed of coagulation increased with particle size; (2) the stability of a colloidal system increased with decreasing particle size; (3) the "critical" potential, the electrokinetic potential at which coagulation of the particles takes place, is dependent on the size of the particles. L.T.B.

Use of paddle viscosimeter for studying variations of viscosity of clay and kaolin suspensions with water and electrolyte content. R. RIEKE AND W. JOHNE. *Ber. deut. keram. Ges.*, **10** [9], 404–24 (1929).—A thorough review of the literature on the subject of viscosity of clay suspensions and methods of measuring viscosity and plasticity is given. Various types of capillary tube viscosimeters and resistance viscosimeters are described. The latter type includes such instruments as the MacMichael torsional viscosimeters and the paddle viscosimeter which was used by R. and J. The instrument used in most of this work was similar to the one used by Bleininger and Brown (*Trans. Amer. Ceram. Soc.*, **11,** 596–604 (1909)) in which a paddle submerged in the material to be tested is rotated by means of a weight. The viscosity-concentration curves for clay-water systems are parabolas when the capillary tube type of viscosimeter is used. When the paddle viscosimeter is used the same curves show maxima and minima. Thus when using the paddle viscosimeter the viscosity of the clay suspensions increases as the clay concentration increases until a certain point is reached, then with a further increase in clay concentration the viscosity decreases and passes through a minimum and further increases in concentration result in a viscosity-concentration curve of parabolic shape. These maximum and minimum points vary in position as the type of clay in the suspension varies. The authors state that the first rise in the viscosity-concentration curve is due to the increase in the number of the individual clay particles while the second rise is caused by the increase in the number of aggregates. The addition of deflocculants moved the maxima and minima to a higher clay concentration. F.P.H.

Friction coefficient for gas flow through small glass tubes. M. ELLIOTT. *Ind., Eng. Chem.*, **20** [9], 923–24 (1928).—E. describes the results of an investigation which was undertaken to determine the possibility of the calibration of flow meters directly without resorting to standardization against a meter. The Fannin equation for fluid

flow was used and the results are plotted on a chart. Tabular data for several gases are included. R.G.M.

BOOKS

Applied Inorganic Analysis. D. F. HILLEBRAND AND G. E. F. LUNDELL. 929 pp. John Wiley & Sons, Inc., New York, 1929. Price $8.50.—An important new work by recognized experts on the analysis of rocks, metals, and minerals. H.H.S.

Bibliography of Bibliographies on Chemistry and Chemical Technology: First Supplement, 1924–1928. NATIONAL RESEARCH COUNCIL. *Bull.*, No. 71, National Research Council, Washington, D. C., 1929. Price $1.50. A supplement to *Bulletin*, No. 50, which covered 1900 to 1924. H.H.S.

La Ceramique Industrielle. Chimie-Technologie. ALBERT GRANGER. Two vols. 920 pp., 560 figs. Price 150F. Gauthier Villars et Cie, Paris. Reviewed in *Rev. mat. constr. trav. pub.*, No. 241, pp. 223–24B (1929); *Brit. Clayworker*, **38** [450], 239 (1929).—This work, amply illustrated and furnished with large numbers of formulas, is of a different class. It is a distinguished work by a professor of the Conservatoire National des Arts et Métiers, and at the upper Ceramic School of Sèvres. Such authorship is a guarantee of a well thought-out and comprehensive book, and if any criticism can be made it is that it is perhaps too comprehensive. It treats ceramic art as applied to all forms of pottery and faience manufacture in a remarkably minute way, invaluable to devotees of those branches of clayworking. After two preliminary chapters on raw materials, the seven other chapters of the first volume treat of (1) tests of materials and analyses of pastes; (2) transparent glazes and colors; (3) preparation of materials; (4) preparation of pastes; (5) fashioning of the ware; (6) drying and kiln setting of pottery; (7) firing of pottery; and (8) glazes and enamels. In the second volume there are chapters on brick and tile, refractories, faience, stoneware, porcelain, and decoration. The book is the work of a master and is worthy of study by all who aim at proficiency in any section of ceramic art. R.A.H.

Hydrogen Ions. HUBERT T. S. BRITTON. Chapman and Hall, London. Price 25s net.—This book gives a most complete treatment of the subject and differs broadly from other works by the amount of general chemistry, both physical and organic, presented in the text. The book appears to be exceedingly well written. It is at once a good analytical text in the best sense and gives references to enough practical industrial applications of hydrogen-ion determinations to permit the well-trained chemist to know what he is doing at all times and to meet a special situation when it arises. Reviewed in *Can. Chem. Met.*, **13** [10], 52 (1929). E.J.V.

Units and Standards of Measurement Employed at the National Physical Laboratory. ANON. H. M. Stationery Office, London, 1929. Price 1s. H.H.S.

Statistical Mechanics. R. H. FOWLER. Cambridge University Press, 1929. *Mech. World*, **86** [2234], 396 (1929).—This volume is based on the Adams Prize Essay for 1924, and it forms an intensive treatment of the subject which forms the basis of examining the motion of a given dynamical system by considering the properties of the related functions as defined by Hamiltonian equations. E.P.R.

Probability and Its Engineering Uses. F. C. FRY. Macmillan and Co., Ltd. London, 1928. *Mech. World*, **86** [2234], 396 (1929).—The application of mathematics as applied to engineering problems is discussed in the book. E.P.R.

Theoretical Mechanics. J. S. AMES AND F. D. MURNAGHAN. Ginn & Co., London, 1929. *Mech. World*, **86** [2234], 397 (1929).—This volume is designed to meet the needs of the reader who is compelled to study the subject without the help of a teacher. An opening chapter is given on vector analysis, and the next four chapters deal with the dynamics of a particle, motion of a rigid body, non-rectilinear motion, and harmonic vibrations. These are followed by others on the Newtonian principle of gravitation,

dynamics of material particle systems, impulsive forces, and motion of rigid bodies about a fixed point. E.P.R.

Determination of Viscosity in Absolute Units: British Standard Method. ANON. 34 pp. British Engineering Standards Assn., London, 1929. Price 2s.—A revised edition of a 1923 publication. A new definition (kinematic viscosity) is made, and there is a new enunciation of Poiseuille's law. Reviewed in *Chem. and Ind.*, **48**, 943 (1929). H.H.S.

PATENTS

Refining borates. WILLIAM A. GALE AND CHARLES FISHER RITCHIE. U. S. 1,732,806, Oct. 22, 1929. In the process of refining borates in the presence of phosphates, the step of adding a sufficient quantity of a relatively soluble salt of a metal forming an insoluble phosphate and a slightly soluble borate to precipitate the phosphate without appreciably precipitating the borate.

Treatment of ores for the recovery of titanium. ARNOLD WILLIAM GREGORY. U. S. 1,734,034, Nov. 5, 1929. Process of removing the iron from titanic iron ores which consists in pulverizing the ore, mixing the pulverized ore with sufficient free carbon to combine with substantially all of the oxygen in the iron oxide of the ore and with a fusible alkaline salt, heating the mixture in the absence of free oxygen to a bright red heat to cause combination of the carbon with substantially all of the oxygen of the iron oxide content and production of free iron in a dispersed state, and immediately treating the whole mass with dilute acid capable of combining with the free iron in quantity at least sufficient to combine with all the free iron, and to neutralize the alkaline salt whereby to resolve all the iron content of the ore to an iron salt in solution.

General

Federated Ceramic Industries Association. ANON. *Brick Clay Rec.*, **75** [9], 547 (1929).—At a conference attended by many professors of ceramics, officers of state associations, and manufacturers in the ceramic industry, at Columbus, Ohio, on September 25, 1929, a proposition regarding the formation of the National Ceramic Industries Association which should be a combination of state representatives of associations in conjunction with the AMERICAN CERAMIC SOCIETY was discussed. It is believed that a national group of this kind will help to further the cause of ceramics more effectively by presenting a united front of all branches of the industry whenever the occasion arises. Through its organization it is hoped that a mutual understanding will be brought to all branches of the industry. Various expressions were given out at the conference regarding the status of coöperation obtained by the ceramic industry in different states. E.J.V.

Ceramic exposition. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **8** [11], 329–30 (1929).—It is pointed out that frequent expositions are as essential as any other activity for the quickest and surest progress in the ceramic arts, science, and technology. Ceramic expositions are proper activities of technical men, and their coöperative organizations logically should sponsor ceramic expositions. The value of such expositions to other than technical men is discussed and it is indicated that ceramic expositions are among our most urgent needs. E.J.V.

Ceramic research council. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **8** [11], 327–28 (1929).—Team work by the different ceramic groups in developing facts relating to materials, processes, products, and markets is very much desired. With this in mind it is pointed out that competition and service demands are getting so severe that there is a monetary reason for close collaboration in the entire ceramic industrial group, indicating the need of a ceramic research council. E.J.V.

State ceramic associations. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **8** [11], 330–31 (1929).—Attention is called to the report of the Conference on State Associations and the reasons for such organizations combining in their efforts to place ceramic materials before the public eye more forcibly are outlined. A working together through committees for the common welfare of the manufacturers of our different ceramic ware is advocated. E.J.V.

Our Annual Meeting. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **8** [11], 328–29 (1929).—Reasons for annual meetings of the SOCIETY are given in conjunction with the notice in regard to the meeting at Toronto, Canada, the week of February 16th. E.J.V.

Lectures on relation of physical chemistry to ceramics. ANON. *Brick Clay Rec.*, **75** [9], 576 (1929).—The Priestley lectures to be delivered at Penn State, December 16–20, 1929, by L. Navias are to be on the following topics: (1) survey of the field of ceramics showing by numerous examples the dependence of ceramics upon physico-chemical principles; (2) the vitreous state of glasses, glazes, and enamels; (3) properties of some important natural materials such as silica minerals, clays, and feldspars; (4) porcelain and similar bodies; (5) shaping refractory oxides; and (6) artificial production of sapphires. E.J.V.

French "Chemistry House." ANON. *Chem. and Ind.*, **48,** 913 (1929).—The Hotel de la Rochefoucauld-d'Estissac in Paris has been acquired by the state as a home for all chemical and chemical industrial societies. H.H.S.

Chemical inventions with special reference to patents. HERBERT LEVINSTEIN. *Chem. and Ind.*, **48,** 980–87 (1929).—Describes patent reform movement initiated by the British Science Guild and coöperated in by the Assn. of British Chemical Mfrs. H.H.S.

Tool lubricants as problems in metal cleaning. F. H. GUERNSEY. *Enamelist*, **6** [10], 36–44 (1929).—Theories of oils, lubrication of metals during working, and effective cleaning of fabricated parts by alkaline detergents are thoroughly discussed. G.H.McI.

Protecting the enamel label as well as the trade mark. WALDON FAWCETT. *Enamelist*, **6** [11], 34–40 (1929).—The label is a separate asset and should be copyrighted and protected by court action with as much care as the registration and protection of the trade mark. G.H.McI.

Diesel plant shows marked economy. E. J. KATES. *Iron Age*, **124** [15], 970–71 (1929).—240 H.P. six cylinder Diesel engine directly connected to 160 kw. generator develops power for 1.2¢ kw.-hr. This power unit has saved 27% of its initial cost in 17 months of operation. E.C.C.

Diesel-fuel oil specifications. ANON. *Mech. Eng.*, **51** [10], 765–67 (1929).—Progress report of the A.S.M.E. special research committee. E.A.H.

Corrosion of boilers checked by electrochemical system. ANON. *Eng. News Rec.*, **101** [6], 209 (1928).—Boiler corrosion is one of the troublesome problems encountered by engineers having charge of steam plants. An electrochemical polarization system that has given satisfactory results when applied to locomotives is said to be applicable also to the boilers of water-works and other utility and industrial plants. This system is briefly described. W.L.

Trends in power-plant development in U.S. and Europe. C. F. HIRSHFELD. *Mech. Eng.*, **51** [10], 727–35 (1929). E.A.H.

Great possibilities of ceramic industry in South. ANON. *Mfrs. Rec.*, **96** [20], 62 (1929).—Florida is using more than 40% foreign floor, wall, and roofing tile. The consumer is almost invariably ignorant of the quality and price of these tile, and in many cases their origin is unknown. Investigations prove that certain architects are forcing an inferior material on their American clients. If this abuse were known there would be

a decided change. There is not a building in the U.S. that could not be substantially and beautifully constructed with none but American material. E.P.R.

Census of manufactures reflects lull in building activity. DEPARTMENT OF COMMERCE. *Brick Clay Rec.*, **75** [9], 546–47 (1929); *Ceram. Ind.*, **13** [5], 492 (1929).—The aggregate value of all clay products and non-clay refractories made in 1928 amounted to $391,265,742, compared with $431,322,184 for 1927 and $458,929,072 for 1926. The total for 1928 was made up as follows: clay products other than pottery, $261,072,227; non-clay refractories, $23,207,238; and pottery, $106,986,277. All but five of the branches of the heavy clay industry report losses in a number of establishments during 1928. A detailed report is given. E.J.V.

Canada's mineral output shows increase for six-month period. ANON. *Can. Chem. Met.*, **13** [10], 27–29 (1929).—A special report on the output of metals and non-metals in Canada to the end of June, 1929, shows a general increase in practically all lines. Non-metallics, other than fuels, showed a gain of 20.3% over the total for the first half of 1928. Large increases in production of magnesite, quartz, feldspar, talc, silica brick, mica, and other non-metallic minerals are reported. E.J.V.

Export expansion. PHILLIPP ROSENTHAL. *Keram. Rundschau*, **37**, 103–10 (1929).—Present obstacles in the way of increasing German exports and various methods of overcoming them are discussed in detail. H.I.

A.S.T.M. Standards Supplement. AMERICAN SOCIETY FOR TESTING MATERIALS. Price $1.50.—This 1929 supplement to the 1927 edition of the "Book of A.S.T.M. Standards" contains 19 revised and 32 newly adopted standards, approved by letter ballot, September 3, 1929. The standards relating to metals and those relating to non-metallic materials appear in the one pamphlet. A report of the Standard Specifications for clay building brick is contained in the book. The pamphlet is thus supplementary to both Part I (Metals) and Part II (Non-Metals) of the 1927 Book of Standards. It is so arranged that the standards supplementing any part of the Book of Standards can easily be separated. Reviewed in *Brick Clay Rec.*, **75** [9], 576 (1929). E.J.V.

Light glare causes eye strain. B. FRANKLIN ROYER. *Abrasive Ind.*, **10** [11], 27 (1929).—Physical exhaustion entirely disproportionate to the amount of energy expended is often caused by eye strain. The American Federation of Labor and the National Society for the Prevention of Blindness are undertaking an educational campaign. E.P.R.

Utilization of sources of natural energy. PAUL DROSNE. *Chaleur ind.*, **10**, 75–77 (1929). A.J.M.

Fundamental principles of handling materials. HAROLD VINTON COES. *Mech. Eng.*, **51** [10], 747–50 (1929). E.A.H.

Fundamentals of management applied to industrial enterprises. L. P. ALFORD. *Mech. Eng.*, **51** [10], 744–46 (1929); see also *Ceram. Abs.*, **8** [5], 378 (1929). E.A.H.

Modern labor relations and the engineer. SAM A. LEWISOHN. *Mech. Eng.*, **51** [10], 736–38 (1929). E.A.H.

Manufacturing statistics and cost calculations. PAUL JÜRGEL. *Keram. Rundschau*, **37**, 139–44 (1929).—This article deals with ceramic industries. H.I.

Accident cost and mine safety. E. H. DENNY. Bur. Mines, *Information Circ.*, No. 6166, 6 pp. (1929).—In the endeavor to reduce mining expense, companies are considering more and more the factors which enter into costs of production; among them the factor of accidents and their cost. This paper endeavors to estimate the approximate cost of accidents to the mining industry in order to present the saving possible through accident reduction or elimination. R.A.H.

Questions relating to lubrication of machines. ERNST W. STEINITZ. *Tonind.-Ztg.*, **53** [50], 885–87 (1929). F.P.H.

Present status of engineering research. CONRAD MATSCHOSS. *Mech. Eng.*, **51** [10], 751–52 (1929). E.A.H.

Attractive brochure on activities of Pittsburgh testing laboratory. ANON. *Amer. Glass Rev.*, **49** [3], 19 (1929).—An attractively designed and printed brochure, descriptive of the activities of the Pittsburgh Testing Laboratory in the field of industrial research and investigation, has just been issued by that organization. The brochure of 32 pp. and cover is profusely illustrated and includes in the subject matter much of interest to those engaged in the glass and ceramic industries. E.P.R.

Phillipp Rosenthal. SIEGFRIED LÖWENSTEIN. *Keramos*, **8** [18–19], 649–52 (1929).—A biographical sketch. F.P.H.

Third National Fuels Conference, Philadelphia. ANON. *Iron Trade Rev.*, **85**, 978–85 (1929).—Sponsored by the Amer. Soc. Mech. Engrs., held at Philadelphia, Oct., 1929. H.H.S.

Grinding wheel makers meet. ANON. *Abrasive Ind.*, **10** [11], 23–24 (1929).—The annual meeting of the Grinding Wheel Mfrs. Assn. of the U. S. and Canada was held at Cresco, Pa., Sept., 1929. E.P.R.

Display abrasive equipment at Tool Builders second exposition. ANON. *Abrasive Ind.*, **10** [11], 10–19 (1929).—The 2nd Exhibition of the National Machine Tool Builders' Assn. held in Cleveland, Sept. 30 to Oct. 4, 1929, demonstrated beyond doubt that abrasive equipment is a major factor in modern production schedules. Comparing this exhibition with the initial one held during the fall of 1927, at the first display 182 manufacturing companies were represented and at the present exhibition 246 manufacturers took part. E.P.R.

Importance of ceramics. ANON. *Amer. Glass Rev.*, **49** [6], 31 (1929); *Nat. Glass Budget*, **45** [28], 13 (1929).—Crockery and Glassware Day was celebrated at the Bankers Industrial Exposition. Alexander Silverman head of the department of Chemistry of the University of Pittsburgh and Ross C. Purdy, general secretary of the AMERICAN CERAMIC SOCIETY were the featured speakers. Mr. Purdy outlined the vital parts played in our daily lives by the various industries which come under the grouping of "ceramics." Dr. Silverman chose as his topic, "Glass: The Indispensable Commodity." E.P.R.

Glass Container Association meeting. ANON. *Glass Ind.*, **10** [11], 271–72 (1929).—A semi-annual convention was held at Toronto, October 17–19, 1929. "The Business Man and His Trade Associations," by Hugh Baker; "Courageous Marketing," by Charles F. Abbott and a report of the activities of the research department by the director, Karl L. Ford. The last two papers are briefly abstracted. E.J.V.

Society of Glass Technology. ANON. *Pottery Gaz.*, **54** [629], 1758–63 (1929).—A report of the presidential address on "Coöperation and Foreign Competition" delivered by Herbert Webb at the October 16th meeting of the Society at Sheffield, is given in considerable detail. E.J.V.

Ceramics in Cuba. ANON. *Ceram. Verrerie*, **49**, 19–25 (1929).—Detailed statistics are given to show the importations into Cuba of pottery, faience, porcelain, and glass. A.J.M.

Ten years of the German Ceramic Society. R. RIEKE. *Ber. deut. keram. Ges.*, **10** [9], 381–404 (1929); *Keramos*, **8** [18–19], 663 (1929).—History and accomplishments of the German Ceramic Society are discussed. F.P.H.

Session of Federation of German Manufacturers of Refractory Products in Kassel, Germany. ANDRES. *Tonind.-Ztg.*, **53** [49], 863–66 (1929). F.P.H.

The Ceramic Society, Refractory Materials Section. ANON. *Engineering*, **128** [3325], 447 (1929).—A résumé of the papers read. A.A.

Meeting of Glass Containers Association, October, 1929. ANON. *Ceram. Ind.*, **13** [5], 494–98 (1929). F.P.H.

The Ceramic Society. H. E. Wood. *Pottery Gaz.*, 54 [629], 1751–58 (1929).—In a report of the recent American tour made by members of the Ceramic Society, W. discussed such items as an American sliphouse, clay pugging, the filterpresses, making the ware, some novel machines, contrast of drying systems used in the U.S. and England, control of firing, liquid and gaseous fuels, tunnel kilns, electric firing, saggers, placing, both bisque and glost, dipping and ware-cleaning, decorating, use of lithographs, "team work" in lithographing, factory layouts, allowing for extensions, mass production and standardization, speeding up, technical research, and some other varied experiences of the trip. E.J.V.

Importance and development of German kaolin industry. Brunner. *Keramos*, **8** [18–19], 669–72 (1929). F.P.H.

United Grossalmeroder Clay Works. Anon. *Tonind.-Ztg.*, **53** [49], 873–74 (1929).—A description is given of the mines and plant of the United Grossalmeroder Clay Works. F.P.H.

Clay industry of Bornholm. Hans Jordt. *Tonind.-Ztg.*, **53** [58], 1035–36 (1929). F.P.H.

New Issue of Manufacturers Register. Anon. *Brass World*, **25** [10], 246 (1929).—Thomas Publishing Co., New York, N. Y., has issued a booklet which contains a very complete register of manufacturers, brands, and trade names and of practically every article and commodity produced by American industry. The book is sold for $15. E.P.R.

BOOK

Picture of World Economic Conditions. National Industrial Conference Board. 253 pp., 6 x 9 in.; published by the board. *Abrasive Ind.*, **10** [11], 25 (1929).—The book is divided into two portions, the first presenting information from various sources on production, wages, employment, prices, trade, and finance. The second portion is made up of original articles specially prepared by foreign correspondents on conditions in their several countries. E.P.R.

Book Review

White Stoneware and Other White Ceramic Bodies. Felix Singer. Published by Deutsche Ton & Steinzeug-Werke, A.-G., Berlin-Charlottenburg, Germany. 16 pp., 14 illus.—White stoneware is actually a new ceramic product occupying the field lying between common stoneware and porcelain. Being compounded from high-grade low-iron clays, instead of kaolins, it is possible to manufacture much larger and more complicated shapes from this material than from porcelain. A comparison is made between porcelain, white stoneware, white earthenware, and sanitary ware with a white slip and glaze. Other special bodies described are one containing corundum (alumina fused in an electric furnace) which considerably increases the fired strength and another with an absorption of less than 0.10% used in the manufacture of large high tension insulators. Mention is also made of an experimental body with a coefficient of expansion only one-quarter that of fused silica which latter material at present has the lowest known value. The physical properties of some newly-developed stoneware bodies are tabulated and compared with porcelain, earthenware, and fireclay sanitary-ware bodies. The application of white stoneware in the chemical field is chiefly in processes where absolute freedom from contamination is essential. In countries with hot climates it has also been found to lessen the heat absorption of apparatus exposed to the sun's rays. Reference is made to a number of exposed installations in Italy where exterior white glazing showed very beneficial results. Reprinted from *Chem.-Ztg.*, No. 11 and 13 (1929); see *Ceram. Abs.*, **8** [9], 666 (1929). F. A. Whitaker

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Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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Vol. 9 **January, 1930** **No. 1**

EDITORIALS

SOCIETY OF RHEOLOGY

The name need surprise no one. It comes from the Greek "Rheo" meaning "to flow." What industry is more interested in this property of its materials than the ceramic industry? Few of us recognize the terms "yield point," "mobility," "surface tension," "adhesion," "cohesion," "shear," "shear stress," "viscosity," and "plasticity" as does the rheologist. To him these terms stand out as sharply defined properties and have for him an almost human appeal.

The new Society brings these rheologists together to enable them to discuss their problems and methods of measurements in an organized way which will result in progress and prevention of duplication. It will, by enabling them to standardize their terminology, assist materially in avoiding the haziness which has so often been associated with these concepts.

The application of the science is extremely broad. It applies to gases and solids as well as liquids. Flow of gases through various media concerns us biologically as well as industrially. Without the control methods de-

veloped by the rheologist there would be little chance to produce biological and colloidal products, vegetable oils, casein products, explosives, Rayon, foods, drugs, paints, varnish insulating resins, asphalt, pitch, lubricants, rubber, soap, and glue, either scientifically or economically.

More recently the student of flow in crystals and other solids has found that his studies are fundamentally the same as those which have been applied to liquids, especially the more viscous ones. Through these concepts our ideas of brittleness, fatigue, annealing, and hardening phenomena are assuming definite form.

All of this speaks for itself as recognition of the value of the science represented by the new Society.

In ceramic plants and ceramic scientific circles we often hear the terms "sticky," "gummy," "jelly-like," "livery," "fluffy," "runny," "short," as well as other colloquialisms. Although we have not realized it, all of these properties can be measured and catalogued by the rheologist. Why then should not the manufacturer of any ceramic product be interested in the application of rheological measurements to his raw clays, glazes, plastic body, slips, casting slips, and enamels as well as perhaps in the firing characteristics of his bodies, glazes, and enamels? It is the writer's hope, therefore, that these remarks may result in greater interest, especially on the part of ceramic research men, in the fundamentals of rheology and the application of these fundamental methods of measurements. We cannot gainsay the fact that empirical methods will take us only a limited distance on the road to successful manufacture.

In line with experience in other fields we can feel sure that clean-cut definitions and careful measurements will serve as helpful guides along this path to success.

The Society of Rheology was organized on April 29, 1929 with Dr. E. C. Bingham, Chairman, and A. Stuart Hunter, Dupont Rayon Co., Buffalo, N. Y., Secretary.

Volume 1, No. 1, of the *Journal of Rheology* was issued in October containing ninety-two pages of original papers, seven pages of Society News, including the Constitution and By-Laws, and twenty-three pages of abstracts of the literature pertaining to rheology, a total of 122 pages.

Wm. W. Buffum, 654 Madison Ave., New York City, is business manager for the *Journal*.

The dues of the Society are $3.00 per year, including a subscription to the *Journal*. Non-members may become subscribers to the *Journal* on payment of $5.00 per year. Corporations, libraries, and societies shall pay the corporation membership of $5.00 per year.

The Chemical Foundation, Inc., has sponsored and carried the cost of organizing the Society of Rheology and issuing the first numbers of the *Journal*.

This Society and its *Journal* are recommended as being greatly worth while to those ceramists who have problems that involve the flow of plastic clay and slips.

SPEND THAT YOU MAY GAIN

There must be a balance between our spending and our saving. To spend recklessly is foolhardy. To save in a miserly fashion is defeating.

A study of the rosters of the AMERICAN CERAMIC SOCIETY for the past thirty-two years reveals that those men who came regularly to Meetings of this SOCIETY, often at their own expense, and who contributed to the programs are occupying high salaried positions.

Those firms that have permitted their men to contribute to the programs have not lost trade advantages. On the contrary, they have given opportunities to their men to develop, to acquire knowledge, and to be known as men who are alert and know their business, thereby increasing their abilities and resourcefulness.

Prestige of the employees is reflected in prestige of the products made.

This search of the SOCIETY'S roster does not reveal a single firm that has handicapped itself or given manufacturing advantages to its competitors by contributing freely to the Meeting programs. On the other hand those firms that have moved forward and are meeting the present high wage (low product price)high product quality demands are those that have helped make successful the several means afforded by this SOCIETY for the development of ceramic men and of ceramic knowledge.

It has been proved that those firms that exchange ideas and knowledge freely and who visit each other's plants, assist one another in developing equipment and processes, and in every way give mutual assistance in producing the highest quality of ware at the lowest cost have not altered their individual trade advantages or changed their relative status as competitors.

We can also find on the rosters of this SOCIETY the names of many individuals and of firms who have advanced in ability while sharing in the affairs of the SOCIETY, but not to the extent of those who have actively participated. And we can find names of persons and firms who have not spent the time and money necessary to attend meetings or do committee work. These, with rare exceptions, are the ones who have not progressed.

One must spend to obtain benefits. There must be a balance between our spending and our saving and that balance is found in spending all that it costs to be among the folks who are accomplishing things worth while. It pays to attend the meetings of this SOCIETY, it pays to participate in the Ceramic Expositions, and it pays to put

time, thought, and money into committee work. Spending on affairs of this sort pays handsome returns.

Rather than saving the cost of participation in the affairs of this SOCIETY one is actually paying a cost for not doing so. This cost shows in lessened abilities and more restricted visions and inspirations. A "live wire" knows that that portion of his earnings which is needed for participation in these activities draws a larger dividend than if all of his earnings are invested in banks and stocks. The more one spends in the affairs of this SOCIETY the more he will have for investment in business, social, and family affairs.

ACTIVITIES OF THE SOCIETY

OUR THIRTY-SECOND ANNUAL MEETING

The preliminary program has been issued. It shows a wealth of papers. But "you aint heard nothin' yet."

The Canadian Committee members have planned big things not yet revealed. They are so busy that they forget that they have not published their program.

Sunday, February 16, will be the pleasantest day of the week. The Board of Trustees and the Committees will have to work all Sunday, but for the others there will be personal meetings, receptions, teas, concerts, city tours, museum visits, and a wonderfully interesting, and by the layman, easily understood colored movie lecture on mineral development and mineral fusions. Sunday will be concluded by a concert of instrumental music on Canada's largest pipe organ and vocal music by a male choir of 200 trained voices.

BRIG.-GENERAL
C. H. MITCHELL

You will have the time and the incentive on Sunday, February 16, for introductions and clubby chats with ceramic men and women from all parts of North America. Old friends will greet, bring up to date, and plan for the future in those ways which make for profitable professional comradeship.

We submit that as valuable as will be the program of papers on Monday, Tuesday, and Wednesday, you will forego fifty per cent of the Ceramic Week in Toronto if you fail to be there Sunday. Much depends on the starting. Be there Sunday.

The genial chairman of the local committee is Brigadier-General C. H. Mitchell, Dean of the School of Science and Engineering, Toronto University, a genial fellow, largely travelled, well educated, easily approached, the "first in war, first in peace, first in the hearts of his countrymen" sort of chap. His whole committee personnel is of the same sort. The Canadians are going to make pleasant your stay with them during Ceramic Week, February 16 to 21, in Royal York Hotel, Toronto.

NEW MEMBERS RECEIVED FROM NOVEMBER 1 TO DECEMBER 1

PERSONAL

Allerton Eddy, Southern Natural Gas Corp., Watts Building, Birmingham, Alabama; Combustion & Natural Gas Engineer.

Adrian C. Hughes, Mellon Institute, Pittsburgh, Pa.; Junior Fellow, Refractories Fellowship.

Alton C. Martin, Calle Zaragoza 1245 Sur, Monterrey, N. L., Mexico; Chief of Technical Dept., Vidriera Monterrey.

Albert L. Register, Jr., Box 293, New Brunswick, N. J.; Secretary and Treasurer, Antimony Products Co.

STUDENT

Ohio State University, Columbus, Ohio

Alfred S. Ault
James Abram Cross
Arthur H. Falter
Glenn A. Hutt
Earl C. Petrie
Ralston Russell, Jr.
Harry W. Thiemecke
Charles Edward Webster

Membership Workers' Record

Personal		Student	
C. E. Bales	1	Office	8
Fred A. Harvey	1		
R. D. Landrum	1	Total	8
Office	1	Grand Total	12
Total	4		

ROSTER CHANGES IN NOVEMBER

Honorary*

Langenbeck, Karl, 2218 Wyoming Ave., Washington, D. C. (616 McGill Bldg.)

Corporation*

Missouri Clay Mining Co., C. L. Gray (voter), Dalton Building, Poplar Bluff, Mo. (Ambassador Bldg., St. Louis, Mo.)

Personal*

Bates, Chas. E., Rossman Corp., Old Bridge, N. J. (Beaver Falls, Pa.)
Bautz, Robert A., Haliburton Hotel, Greenview and Morse, Chicago, Ill. (1413 Dobson St., Evanston, Ill.)
Butler, Joseph F., 338 West 23rd St., New York, N. Y. (154 E. 64th St.)
Burnand, Guy M., Johnson Matthey & Co., Inc., 15 West 47th St., New York, N. Y. (London, E.C. 1, England)
Christopher, A. B., 325 Pine St., Audubon, N. J. (Merchantville, N. J.)
Cooke, Raymond D., Rundle Mfg. Co., 1550 Forest Home Ave., Milwaukee, Wis. (National Enameling & Stamping Co., Granite City, Ill.)
Dailey, James G., Box 936, Toledo, Ohio. (323 20th St.)
DeVoe, Chas. H., Kenilworth Tile Corp., Newell, W. Va. (New Brunswick, N. J.)
Felton, Thomas M., Shepherd Chemical Co., Cincinnati, Ohio. (Pittsburgh, Pa.)
French, Gordon E., Box 48, Perth Amboy, N. J. (Rochester, N. Y.)
Gould, Robert E., Wilhelmstrasse 34, Beuthen, O/S, Germany. (Chester, W. Va.)
Grainer, John S., 734 Griggs St., Grand Rapids, Mich. (754 Griggs St.)
King, Melvin Mason, 25 E. 4th St., Corning, N. Y. (P. O. Box 261)
Kleerup, N. O. Alex, 2708 Channing Way, Berkeley, Calif. (Pittsburgh, Calif.)
Kuechler, A. H., 2729 Edgehill Road, Cleveland Heights, Ohio. (Cloverport, Ky.)
Martz, Joseph A., 133 Bane Ave., Newton Falls, Ohio. (16 Church St.)
Matzen, Harry B., 1824 Union Trust Bldg., Cleveland, Ohio. (923 Union Trust Bldg.)
Mayfield, Chester C., 707 W. High Ave., New Philadelphia, Ohio. (Toledo, Ohio)
McFadon, Everett O., Ferro Enamel Supply Co., Keith Building, Cleveland, Ohio. (St. Louis, Mo.)
Meyer, William W., 295 East 8th Ave., Columbus, Ohio. (Palo Alto, Calif.)
Morgan, Raymond W., 6105 N. Talman Ave., Chicago, Ill. (Indianapolis, Ind.)
Opperman, R. H., 1401 Arch St., Philadelphia, Pa. (Membership transferred from William E. Saunders)
Pearson, J. Donald, 325 N. Washington, Ottumwa, Iowa. (Mansfield, Ohio)
Perrine, Charles F., 316 East Front St., Red Bank, N. J. (36 Riverside Ave.)
Rhode, Irma, 5316 Pershing Ave., St. Louis, Mo. (5428 Murdock Ave.)
Rice, Bryan A., The Pfaudler Co., Lincoln Park Factory, Rochester, N. Y. (Pittsburgh, Pa.)
Richardson, Gordon B., Gladding McBean & Co., 621 S. Hope St., Los Angeles, Calif. (Alberhill, Calif.)
Roth, H. A., Rundle Mfg. Co., 38th & River Road, Camden, N. J. (Milwaukee, Wis.)
Saxe, C. W., 18 Clearview Ave., Worcester, Mass. (54 W. Boylston St.)
Schofield, H. Zane, Standard Tile Co., Zanesville, Ohio. (Columbus, Ohio)
Schweickhardt, William K., Alabama Polytechnic Institute, Box 2336, Auburn, Ala. (St. Louis, Mo.)
Shearer, Walter L., Rouse & Shearer, Inc., 67 Oxford St., Trenton, N. J. (163 Bloomsbury St.)

* Addresses within the parentheses ( ) represent the old address.

Simpson, Harold E., Ceramic Dept., Rutgers University, New Brunswick, N. J. (Columbus, Ohio)
Smith, James R., Sr., 1811 Brunswick Ave., Trenton, N. J. (2007 Brunswick Ave.)
Starr, C. D., 9 Codding St., Providence, R. I. (P. O. Box 1342)
Stephenson, H. H., Post Office, Auckland, New Zealand. (Vancouver, B. C., Canada)
Strong, Kenneth B., 7653 Oglesby Ave., Windsor Pk., Chicago, Ill. (2539 E. 77th St.)
Suydam, A. G., Hearst Bldg., San Francisco, Calif. (412 Hobart Bldg.)

These roster changes which are published each month may be checked against the complete Membership Roster which was published in the July, 1929, issue of the *Bulletin*. Copies of this issue may be obtained from the Secretary's office, price $2.00.

LOCAL SECTION MEETINGS

Baltimore-Washington Section

The first meeting of the 1929–1930 season of the Baltimore-Washington Section was held in Washington, D. C., on November 23, 1929. Dinner was served at the Tilden Gardens Club after which the members adjourned to the Bureau of Standards.

The address of the evening was given by Dr. Frank H. H. Roberts of the Smithsonian Institute. His topic "Prehistoric Southwest Americans and Their Pottery" differed from the usual programs of this Section, in that it was nontechnical.

The progress of Indian pottery was traced from the earliest dried clay baskets to the present-day decorated tableware and the parallel development of Indian civilization and pottery was emphasized. The method of fixing dates of the different specimens of pottery by utilizing the annual rings of timbers found in old Indian homes as a measure, was explained. The fact was also pointed out that the ceramic knowledge of the Indians was acquired quite accidentally and never included the use of glazes.

Thirty-one members of the Section attended the lecture and twenty-two the dinner which preceded it. Those present at the dinner were Mr. and Mrs. W. N. Harrison, Dr. and Mrs. H. Insley, Mr. and Mrs. J. W. McBurney, Mr. and Mrs. R. T. Stull, and Messrs. A. Creamer, D. W. Fuller, J. F. Klekotka, L. A. Palmer, and L. E. Mong.

Those from Baltimore were Mr. and Mrs. R. A. Blunt, Mr. and Mrs. L. J. Trostel, R. R. Barr and son, and R. R. Fusselbaugh.

The officers for this Section are as follow:

Chairman: W. A. Weldon, Locke Insulator Corp., Baltimore, Md.
Vice-Chairman: W. N. Harrison, Bureau of Standards, Washington, D. C.
Secy.-Treasurer: L. E. Mong, Bureau of Standards, Washington, D. C.
Councillor: L. J. Trostel, General Refractories Co., Baltimore, Md.

Pittsburgh Section

At the last meeting of the Pittsburgh Section held on December 10, 1929, the following officers were elected for the 1929–1930 season.

Chairman: P. D. Helser, Eljer Co., Ford City, Pa.
Vice-Chairman: R. F. Ferguson, Mellon Institute, Pittsburgh, Pa.
Secretary: Robert C. Boyd, Standard Sanitary Mfg. Co., Pittsburgh, Pa.
Treasurer: Jack Waggoner, Mellon Institute, Pittsburgh, Pa.
Councillor: E. W. Tillotson, Mellon Institute, Pittsburgh, Pa.

W. C. Taylor of the Corning Glass Works gave a talk on "Glass Manufacturing Control." A partial list of those who attended the meeting is given.

Joseph Early, *Amsler-Morton Co.;* H. S. Hower, *Carnegie Institute of Technology;* R. Bedson, S. Bedson, G. E. Crawford, P. D. Helser, and Geo. A. Wills, *Eljer Co.;* H. A. Wakefield, *Equitable Gas Co.;* D. W. Ross, *Findlay Clay Products Co.;* S. R. Scholes, *Fostoria Glass Co.;* C. F. Brashares, F. A. Harvey, R. H. Pierce, and B. C.

Ruprecht, *Harbison-Walker Refractories Co.;* F. C. Flint, A. K. Lyle, *Hazel-Atlas Glass Co.;* E. M. Hommel, *O. Hommel Co.;* S. M. Swain, *Kier Fire Brick Co.;* F. R. Meyers, *Laclede-Christy Co.;* Harold E. White, *Lava Crucible Co.;* H. H. Blau, D. C. Evans, Weston H. Gillette, W. N. Stoveman, and Roy C. Swain, *MacBeth-Evans Glass Co.;* E. J. Casselman, G. R. Daniel, R. F. Ferguson, P. F. Siegrist, E. W. Tillotson, George Walther, and Jack Waggoner, *Mellon Institute;* G. A. Bole, *O. S. U. Eng. Expt. Station, Columbus, Ohio;* J. Gregorius, *Pittsburgh Plate Glass Co.;* Theo. Lenchner, Harry O. Richard, *Roessler and Hasslacher Co.;* T. J. Hughes, *Tygart Valley Glass Co.;* L. R. Kirk, W. K. McAfee, *Universal Sanitary Mfg. Co.;* A. Silverman, F. J. Williams, M. H. Biglowe, *Univ. of Pittsburgh;* W. E. Rice, *U. S. Bureau of Mines;* H. G. Willetts, H. G. Willetts, Jr., *The Willetts Co.;* H. W. Baque, *Woods Lloyd Co.*

NOTES AND NEWS

NEWS FROM THE CERAMIC SCHOOLS

Ohio State University[1]

The Ceramic Engineering Department has moved back into the offices on the main floor of Lord Hall which it originally occupied, but which for the past fifteen years have been occupied by the offices of the College of Engineering. The Engineering College offices have been temporarily located in the new Chemistry Building. The museum of the Ceramic Engineering Department has also been removed to the main floor of Lord Hall and will be enlarged. The room vacated by the Ceramic Engineering offices will be converted into a much-needed class room. The engineering drawing of the Ceramic Engineering Department has been transferred to the large drafting room on the top floor, east end of Lord Hall and the room vacated has been converted into three research rooms for post-graduate students.

Special Course on Plaster of Paris and Other Gypsum Products

The Ohio State University Student Branch of American Ceramic Society is announcing a course of lectures and demonstrations on "Gypsum Products, Their Manufacture and Use," by the Engineering Staff of the U. S. Gypsum Company. Lectures at 3:00 and 7:30 P.M., January 15 and 16, 1930. This course will provide information that every user of plaster of Paris and other gypsum products is seeking and will be strictly educational. All who are interested are welcome. No fee. Copy of the program may be obtained from the Ceramic Engineering Department, Ohio State University, Columbus, Ohio.

Meeting of the Student Branch of American Ceramic Society

The Student Branch of the American Ceramic Society held its monthly business meeting Thursday, December 12, at Lord Hall.

F. M. Hartford, Vice-President of the Harrop Tunnel Kiln Company of Columbus, Ohio, was the principal speaker of the evening. His topic was "What the Employer Expects of the Ceramic Engineer."

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[1] Glenn A. Hutt, *Corresponding Secretary.*

SHORT COURSES AT THE UNIVERSITY OF ILLINOIS*

Heavy Clay Products

A full week of lectures will be given in Heavy Clay Products, January 20 to 25, at the University of Illinois. This course is in conjunction with the Bodies and Glazes and the Enamels short courses at the same institution.

Time	Jan. 20 (Mon.)	Jan. 21 (Tues.)	Jan. 22 (Wed.)	Jan. 23 (Thurs.)	Jan. 24 (Fri.)	Jan. 25 (Sat.)
9	Welcome by Dean M. S. Ketchum	Properties of Clays (3) Carbon	Properties of Clays (5) Lime	Properties of Clays (7) Vitrification	Properties of Clays (9) Non-plastics	Properties of Clays (10) Testing
10	Properties of Clays (1) Silica	Drying (2)	Drying (4)	Kilns and Firing (2)	Kilns and Firing (4)	Kilns and Firing (6)
11	Preparation (1) of Clays	Preparation (2) of Clays	Excavation and Haulage (1)	Excavation and Haulage (2)	Grain Size and Body Strength	Pyrometry
2	Properties of Clays (2) Sulphur	Properties of Clays (4) Water	Properties of Clays (6) Soluble Salts	Properties of Clays (8) Color	Method of Control	Methods of Control
3	Drying (1)	Drying (3)	Kilns and Firing (1)	Kilns and Firing (3)	Kilns and Firing (5)	Heat Balance

* Anyone interested can obtain an application blank or further information by writing the Ceramic Department, University of Illinois, Urbana, Illinois. No fee is charged for these courses.

SHORT COURSES AT THE UNIVERSITY OF ILLINOIS (*continued*)

Bodies and Glazes

The Short Courses in Ceramics at the University of Illinois include five days, January 27 to 31, devoted entirely to the subjects of Bodies and Glazes as shown in the following program:

Time	Jan. 27 (Mon.)	Jan. 28 (Tues.)	Jan. 29 (Wed.)	Jan. 30 (Thurs.)	Jan. 31 (Fri.)
10	Raw Materials (1)	Raw Materials (2)	Raw Materials (3)	Glaze Types (2)	Glaze Types (3)
11	Drying (1)	Drying (2)	Kilns (2) and Burning	Body Tests	Pyrometry
2	Body Materials (1)	Body Materials (2)	Body Compositions	Casting Bodies	Body Faults
3	Glaze Calculations (1)	Glaze Calculations (2)	Glaze Types (1)	Glaze Faults	Glaze Testing
3	Saggers	Kilns (1) and Burning	Kilns (3) and Burning	Microscope Demonstration	Refractories

Vitreous Enameling

The Short Courses in Ceramics at the University of Illinois include five days, January 27 to 31, devoted exclusively to Vitreous Enameling. The following subjects will be taken up.

Time	Jan. 27 (Mon.)	Jan. 28 (Tues.)	Jan. 29 (Wed.)	Jan. 30 (Thurs.)	Jan. 31 (Fri.)
9	Raw Materials (1)	Raw Materials (2)	Raw Materials (3)	Acid Resisting Enamels	Effects of Gases of Combustion
10	Iron and Steel (1)	Enamel Calculations (1)	Mill Additions	Application	Pyrometry
11	Iron and Steel (2)	Types and Compositions (1)	Opacity	Enamel Calculations (2)	Enamel Tests
2	Metal Preparation (1)	Types and Compositions (2)	Milling (1)	Burning (1)	Fuels and Furnaces
3	Metal Preparation (2)	Smelting	Milling (2)	Burning (2)	Refractories

IOWA STATE COLLEGE

Short Course for Clayworkers*

January 22, 23, 24, 25, 1930

Wed.	9:00 A.M.	Registration, Room 105, Engineering Hall.
		Inspection Trips.
	1:30 P.M.	Opening Address by Paul E. Cox, Head Ceramic Eng. Dept., I. S. C.
		A New Method of Salt Glazing by J. Otis Everhart.
		Gas and Arc Welding Demonstration.
Thurs.	9:00 A.M.	Welding Conference. Discussions on Gas and Arc Welding in Plant Maintenance.
		Hard Facing Wearing Parts.
	1:00 P.M.	Clay Products Motion Pictures.
		Use of Clay Products in Farm Buildings by Henry Giese, Agric. Eng. Dept. and Paul E. Cox.
		Light Weight Aggregate.
Fri.	9:00 A.M.	The Stiff-Mud Machine by D. A. Moulton, Ceramic Eng. Dept.
		Augers for Stiff-Mud Machine by Representative, Chambers Bros. Co.
		Discussions on Stiff-Mud Machine.
	1:00 P.M.	The Use of Wood Dies in Solving Die Troubles by D. A. Moulton, Ceramic Eng. Dept.
		Dies for Stiff-Mud Machines, Representative Louisville Machine Mfg. Co.
		Discussion of Dies.
Sat.	9:00 A.M.	Clay Products Motion Pictures.
		Power Transmission—Belts and Chain Drives.
		Fans and Blowers by A. K. Freidrich, Mining Eng. Dept.

CUSHMAN FELLOWSHIP AWARD

The Cushman Fellowship Award in enamels has been given to Thomas Morris, Western Reserve University, Cleveland, Ohio. Mr. Morris succeeds Royal Bryant who is now studying under a Rhodes Scholarship at Oxford, England. The Cushman Fellowship Award was founded several years ago by H. D. Cushman, President, The Ferro Enameling Co., Cleveland, for the investigation of fundamental chemical reactions of vitreous (silicate) enamels. Previous to receiving the Fellowship, Mr. Morris was chemist for the Brown Co., Berlin, N. H. He is a graduate of Brown University.

GENERAL CONFERENCE ON FELDSPAR

Washington, D. C., January 14, 1930

At the request of the Feldspar Grinders' Institute, a general conference has been called at the Bureau of Standards, East Building, at 10 A.M., Jan. 14, 1930. The standardization of grades for the classification of feldspar on the basis of the proposed standard will be discussed.

* There are no fees in connection with this course. Anyone interested in the manufacture of clay products is invited to attend. Address any inquiries concerning this course to Ceramic Engineering Dept., Iowa State College, Ames, Iowa.

The meeting has been called by Harry H. Steindle, Division of Trade Standards, Dept. of Commerce.

Proposed Commercial Standard for Feldspar

(1) Scope

This Commercial Standard covers ground feldspar used in the production of ceramic products, based on particle size and chemical composition.

(2) General Requirements

All screen tests shall be made on standard screens (U. S. Stand. Sieve Series), the opening sizes and diameters of which are appended to Table I, and according to the standard method of testing described.

All chemical analyses shall be made according to the standard method given below.

(3) Detail Requirements

(a) Physical Classification Based on Fineness of Grinding*

TABLE I

Mesh		Percentage remaining on 200-mesh screen	Maximum percentage on mesh designated	Standard screens openings (inches)		
U. S. standard sieve series no.	Mfrs. no.			U. S. stand. sieve series	Tolerance % in average opening	Mfg. stand.
230	250	0.00–0.35	1.0	0.0024	±8	0.0024
200	200	0.35–1.00	1.0	0.0029	±8	0.0029
170	170	1.00–2.50	1.0	0.0035	±8	0.0035
140	150	2.50–5.00	1.0	0.0041	±8	0.0041
120	115	5.00–9.00	1.0	0.0049	±6	0.0049
100	100	9.00–14.00	1.0	0.0059	±6	0.0058
80	80	14.00–21.00	1.0	0.0070	±6	0.0069
60	60	21.00–30.00	0.6	0.0098	±6	0.0097
40	35	30.00–42.00	0.3	0.0165	±5	0.0164
20	20	42.00–62.00	None	0.0331	±5	0.0328

* Fineness classification shall be made on a basis of the percentage remaining on the standard 200-mesh sieve and that remaining on the sieve of the designated mesh. Example: 140-mesh product will have 2.5 to 5.0% remaining on the 200-mesh sieve and less than 1% on the 140-mesh sieve.

(b) Chemical Classification Based on Composition as It Influences Use

The first group includes the commonly accepted ceramic or body grades based on silica content and alkali ratio and containing less than 4% soda (Na_2O) content.

The silica and ratio numbers are to be used in combination: *e.g.*, Grade 68 to 51 designates a feldspar of silica content up to 68% and with 5 or more parts of potash (K_2O) to 1 part of soda (Na_2O).

Number	Silica (SiO_2) content
68	Up to and including 68%
69	Above 68% up to and including 70%
70	Above 70% up to and including 72%
72	Above 72%
	Potash (K_2O)–Soda (Na_2O) ratio
51	5 or more potash to 1 soda
41	More than 3 and less than 5 potash to 1 soda
31	3 or less potash to 1 soda

The second group includes the feldspars used chiefly for glazing purposes which are based on soda content and contain 4% or more soda (Na_2O).

Number	Soda (Na_2O) content
4	4 to 5% not including 5%
5	5 to 6% not including 6%
6	6% and above

The third group includes feldspars used for the manufacture of glass. These are based on alumina (Al_2O_3) content.

Number	Alumina (Al_2O_3) content
15	Below 16% not including 16%
16	16 to 17% not including 17%
17	17 to 18% not including 18%
18	18 to 19% not including 19%
19	19% and above

The fourth group are "off color" feldspars based on iron content.

	Iron oxide (Fe_2O_3) content
X	0.17 to 0.50% not including 0.50%
XX	0.50 to 1.00% not including 1.00%
XXX	1.00% and above

(4) Standard Methods of Test

(a) Physical Test

Mesh or Fineness A 100-gram portion of the dry sample is weighed out to an accuracy of 0.1 gram. It is then transferred to the 200-mesh sieve and over a sieve pan which fits closely enough to prevent loss by slopping. The pan shall contain sufficient water to reach within not less than $^1/_4$ inch or more than $^3/_4$ inch from the top of the pan. The sieve and pan shall be vibrated or shaken in such a manner that water in the pan is splashed on the screen from below, so as to wash the powder about and cause the material that can pass through the sieve to pass into the pan below. This treatment shall be continued until no appreciable amount is passing through. The contents of the screen are then washed into a pan and thoroughly dried. The dried material is then placed on the coarsest sieve to be used. The finer screens including the 200-mesh are placed in order of size under the coarsest, the 200-mesh being at the bottom. The tier of screens is then shaken until no more than 0.05 of a gram passes any screen after 1 minute of shaking each time. This point is determined by weighing the residue on the coarsest screen, reshaking for a minute until finished, then going to the next size, and repeating the process.

(b) Chemical Tests

Precautions All work shall be checked against the Bureau of Standards, Standard Sample No. 70 Feldspar.

Dry sample at 105 to 110°C.

Correct results by blanks on reagents.

Factors to be determined from latest molecular weights.

Silica Fuse 1-gram sample with 6 grams sodium carbonate in 25 cc. platinum crucible. Gradually raise flame to full heat and continue until fusion is quiescent. Rotate while hot to cause it to solidify in a thin sheet on the sides of the crucible. Remove with water and stirring rod to a 250-cc. casserole. Add hydrochloric acid in excess gradually to avoid spattering, keeping cover glass on casserole. Heat and stir until carbonates are dissolved. While taking up with acid, as above, let crucible stand with a little hydrochloric acid and water to fill it. Transfer this crucible content to casserole and wash. Break up remaining lumps with stirring rod. Remove and wash cover glass. Evaporate in casserole to dryness. Moisten with concentrated hydrochloric acid, add equal volume of water, place on bath on hot plate for 5 minutes, add about 100 cc. water, heat 5 minutes, and filter boiling hot. Wash twice with 1:3 hydrochloric acid, once or twice with cold water, then wash with *hot* water until free from chlorides. Evaporate filtrate and washings in same casserole. Dehydrate at 120°C for 30 minutes. Moisten with hydrochloric acid and equal volume of water; heat 10 minutes. Dilute with

100 cc. water, heat to boiling, and filter through second filter. Wash with cool dilute hydrochloric acid (1 : 99). Transfer filters to platinum crucible, weighed, and placed over flame so that heat strikes cover and is reflected onto filters. Dry in this manner with low flame. When charred on top, move flame to base of crucible, raise flame, and ignite with cover slightly ajar until nearly white, then blast 20 to 30 minutes with cover tight. Cool 30 minutes in desiccator and weigh as SiO_2 plus impurity. Moisten with 1:4 sulphuric acid, add 10 cc. hydrofluoric acid, and stir with platinum wire until dissolved. Evaporate and remove sulphuric acid over flame. Ignite strongly for a minute or two, giving air free access to crucible, and weigh as Al_2O_3 plus Fe_2O_3 residue. Subtracting this residue from the silica plus impurities gives the SiO_2 content.

Alumina and Iron Oxide Dilute silica filtrate to about 300 cc. and heat to boiling. Add two drops methyl red, then ammonia to change color. Boil one or two minutes and filter at once. Wash twice with 2% ammonium chloride. Dissolve precipitate through filter into original beaker with 1:2 hydrochloric acid. Punch hole in filter and wash clean. Dilute to 300 cc. Tear up filter and place in beaker with the dissolved precipitate. Precipitate and filter at boiling as above. Wash five times with hot 5% ammonium chloride solution. Test filtrate and if precipitate appears, filter it separately. Wash and add residue to large precipitate. Ignite wet in crucible holding silica residue, or tared crucible in the same manner as for silica. Care must be taken to see that carbon is burned off in the bottom as it is often necessary to turn the precipitate over with a platinum wire. Cool, weigh, and subtract the weight of the empty crucible to obtain the weight of "Al_2O_3 plus Fe_2O_3."

Lime Combine the filtrates from the Al_2O_3 plus Fe_2O_3, dilute to about 400 cc., boil and slowly add 10 cc. of a hot 4% solution of ammonium oxalate. Let solution set over night in warm place. Filter and wash with 0.1% solution of ammonium oxalate. Dissolve residue in hydrochloric acid. Add ammonia and precipitate as before, this time adding a small amount of oxalate. Filter, wash, ignite, and weigh as CaO.

Magnesia Acidify calcium filtrates. Add an excess of a saturated solution of secondary ammonium phosphate, then ammonium hydroxide slowly and with stirring until the solution is ammoniacal and finally add 10 cc. in excess per 100 cc. of solution. Set over night, filter and wash immediately with dilute ammonia hydroxide (5:95). Dissolve the precipitate in dilute hydrochloric acid (1:9), add 1:3 cc. of saturated phosphate solution and precipitate as before. Ignite cautiously and at a low temperature until carbon is destroyed and then at 1100–1150°C. Weigh as $Mg_2P_2O_7$ and calculate as MgO.

Soda and Potash Take 0.5-gram sample. Grind fine in agate mortar. Add 0.5 gram ammonium chloride and grind mixture to impalpable powder. Add 3 grams precipitated calcium carbonate and mix *thoroughly*. Transfer to glazed paper, then to 25 cc. platinum crucible. Clean mortar with 1 gram calcium carbonate and add to crucible contents. Cover crucible with a snugly fitting cover and place over flame in $^1/_8$-inch thick asbestos sheet so that a little less than half of the crucible is exposed to the flame. Heat gently so odor of ammonia is just plainly distinguishable. Gradually raise the heat until ammonia cannot be smelled, then sinter for one hour with fairly full flame, especially at the last. During sintering put small beaker of water on crucible cover. Transfer sintered cake to 250-cc. casserole, add 100 cc. water and boil, also fill crucible with water and heat for a while. Decant through filter into 1250 cc. casserole. Repeat boiling and decanting through filter using about 50 cc. of water each time until only traces of chloride are present, then transfer residue to filter and wash twice with hot water. This cannot be done in less than three hours as a rule. Add 20 cc. of a saturated solution of ammonium carbonate and evaporate to a volume of 25 to 100 cc. Add 10 cc. ammonium carbonate. Filter into 250 cc. casserole, washing free from chlorides. Evaporate to 10 cc. Add 2 drops ammonia and excess ammonium oxalate (a few drops) and let set over night. Filter through $5^1/_2$ cm. filter into 75 cc. platinum dish. Wash moderately with a 0.1% solution of ammonium oxalate. Evaporate to dryness finishing in oven at 110°C. Ignite after drying at 110°C until ammonium salts are volatilized. Dissolve in a little hot water. Filter into small porcelain dish and transfer back to 75-cc. platinum dish which has been weighed. Evaporate to dryness, dry at 110°C. Ignite to dull red, cool in desiccator, and weigh as NaCl plus KCl. Add 20 cc. hot water, a drop hydrochloric acid and 1 to 2 cc. perchloric acid, specific gravity 1.54, 60%. Evaporate to dryness at a temperature not over 350°C; cool, add 20 cc. absolute ethyl alcohol containing 0.2% perchloric acid. Break up residue, let stand 15 minutes, filter through tared Gooch crucible, and wash six times with the above alcohol that has been saturated with potassium perchlorate. Drain thoroughly and dry 1 hour at 120°C. Cool and weigh as potassium perchlorate ($KClO_4$).

Weight of $KClO_4$ × factor	= KCl
Weight of $KClO_4$ × factor	= K_2O
Total chlorides minus KCl	= NaCl
NaCl × factor	= Na_2O

Iron Oxide To five-gram sample in a platinum or other resistant dish add 20 cc. of 1–3 sulphuric acid. Add about 40 cc. hydrofluoric acid and stir vigorously with platinum wire. Evaporate to expel hydrofluoric acid and silicon tetrafluoride on water bath. Fume sulphuric acid by keeping in motion over low flame. Cool, add water, and 5 cc. concentrated hydrochloric acid. Heat to boiling and reduce with stannous chloride, avoiding excess. Add 10 cc. of a saturated solution of mercuric chloride and after three minutes pour into at least 500 cc. cold water. Add 20 cc. titrating solution and titrate with potassium permanganate solution.

NOTE: Stir while evaporating hydrofluoric acid and silicon fluoride and correct results by a blank run on reagents.

$SnCl_2$ Solution Dissolve 50 grams of stannous chloride in 100 cc. hydrochloric acid. Dilute to 1000 cc. with water.

Titrating Solution Dissolve 67 grams manganese sulphate in water. Add 138 cc. phosphoric acid and 130 cc. concentrated sulphuric acid. Dilute to 1 liter.

$KMnO_4$ Standard 1.05 grams per liter. Dissolve 0.1 gram Bureau of Standards sodium oxalate in 500 cc. hot water. Add 15 cc. manganese sulphate titrating solution. Titrate drop by drop to pink.

Free Iron Cover 10 grams of sample with concentrated hydrochloric acid. Add 2 cc. stannous chloride. Cover and heat one hour. Reduce with stannous chloride. (If colorless oxidize with permanganate, then reduce.) Cool. Add 10 cc. mercuric chloride. Dilute, add 20 cc. titrating solution, and titrate with permanganate standard.

Loss on Ignition Heat 5-gram sample $^1/_2$ hour in tared crucible with full force of burner; cool and weigh; use this sample for Fe_2O_3 determination.

ENAMELERS' TRAINING COURSE

The 1929 Enamelers' Training Course was held in Cleveland on December 2 to 14, inclusive. The Course was sponsored by the Ferro Enameling Co., and the sessions were held in their plant.

Laboratory and shop demonstrations were used to supplement the textbook in-

struction given by J. E. Hansen, research engineer for the Ferro Enameling Co. Mr. Hansen's textbook, The Technique of Enameling, was used to form the background for this course.

OHIO CERAMIC INDUSTRIES ASSOCIATION

Fall Meeting—Barbecue Luncheon

The Ohio Ceramic Industries Association held its Fall Meeting at Lord Hall, Ohio State University, on Friday and Saturday, November 8 and 9, with an attendance of approximately 200.

The Heavy Clay Products, Whiteware, and Refractories Divisions held separate technical sessions Friday morning and afternoon. All divisions met together for a general planning and business meeting Saturday morning.

The meeting ended with a pig roast dinner, complimentary by the Columbus ceramists, with R. C. Purdy, in the capacity of chef, ably assisted by J. D. Martin, J. L. Murphy, C. F. Tefft, Carl B. Harrop, Frank Hartford, E. P. Ogden, and M. C. Booze wielding carving knives.

The following officers were elected for the coming year:

President: W. Keith McAfee, Universal Sanitary Mfg. Co., New Castle, Pa.
Vice-President: C. H. Taylor, Chas. Taylor Sons Co., Cincinnati, Ohio.
Treasurer: C. B. Harrop, Harrop Ceramic Service Co., Columbus, Ohio.
Secretary: H. E. Nold, Mine Engineering Department, O. S. U., Columbus, Ohio.

The following divisional chairmen were elected:

Whiteware: T. B. Anderson
Refractories: C. E. Bales
Heavy Clays: F. M. Hartford

Heavy Clay Products Division

The Friday forenoon session with F. M. Hartford presiding, was devoted to discussions led by H. C. Harrison, Tajamul Husain, and J. O. Everhart, research engineers at the O. S. U. Ceramic Experimental Plant at Roseville, Ohio.

Messrs. Harrison and Husain discussed "The Use of Electrolytes to Improve Heavy Clay Products."[1]

The afternoon session was devoted to the following subjects:

(1) "A Discussion of Ceramic Materials from the Architects' Point of View," led by Howard Dwight Smith and W. A. Paine from the Columbus Chapter, American Institute of Architects, and R. C. Kempton from the Allied Architects' Assn. Professor C. St. John Chubb of the Dept. of Architecture, O. S. U., also participated in the discussion.

(2) "The Need for Engineering Information and Service in the Promotion and Sale of Ceramic Materials," by L. B. Lent, Common Brick Mfrs. Assn.

(3) "What the Engineer Needs in Engineering Data on Ceramic Materials," by C. T. Morris, Prof. of Structural Engineering, O. S. U.

White Wares Division

The forenoon session was opened with a paper by H. M. Kraner, Westinghouse Electric & Mfg. Co., Pittsburgh, Pa., on the subject "Proposed Plans for Coöperative Research and the Exchange of Data between Whiteware Plants."

A round table discussion of research work in the whiteware industry which should be undertaken by the Engineering Experiment Station, O. S. U. followed.

"Trend of the American Market in Tableware from the Buyers' Point of View" was presented by M. J. Hinterschied, of the Wm. Hinterschied Co., dealers in tableware and house furnishings, Columbus, Ohio.

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[1] See Ohio State Univ., *Eng. Expt. Station News*, Sept., 1929.

"What the Manufacturer Is Doing to Meet the Market Demands" was discussed by Col. J. C. Heckman, President of the American Chinaware Corp.

The chairman was authorized to appoint a Committee to coöperate with the Engineering Experiment Station, O. S. U., in promoting and organizing a program of whiteware research.

Refractories Division

The morning session opened with Charles Taylor, Chairman of the Division, presiding.

R. E. Birch, research ceramic engineer, O. S. U., Eng. Expt. Sta., reported on the present status of the research work on dry-press refractories. This work is being done on a hydraulic press in an attempt to determine the effect of various forming pressures on the finished products.

A discussion on "Drying and Shrinkage Problems" opened the afternoon session and was led by M. C. Booze.

C. E. Bales of the Ironton Fire Brick Co. discussed "How Will the Adoption of a Three-Inch Brick as Standard Effect Production."

Mr. Fredericks reported recent success in the manufacture of a new silica refractory from the Sharon Conglomerate at the plant of the Portsmouth Refractories Co., Portsmouth, Ohio. This conglomerate has a silicon content of from 93 to 98% at Portsmouth.

THE ADELAIDE ALSOP ROBINEAU EXHIBIT OF PORCELAIN

The Metropolitan Museum of Art has announced the opening of an exhibition of seventy-one pieces of porcelain by the late Mrs. Adelaide Alsop Robineau, which opened on November 18, 1929, and will continue until January 19, 1930. Mrs. Robineau's work holds an enviable place among the foremost potters of any country and this exhibit will be the largest collection of her work ever assembled.

JOSIAH WEDGWOOD BICENTENARY*

Historial Pageant Episodes—Outline of Military Tattoo

An outline is given of the Historical Pageant and Military Tattoo which will be the two most spectacular features of the Josiah Wedgwood Bicentenary Celebrations next May. The Pageant will consist of nine episodes, as follows:

(1) An early British episode at the time of the Roman occupation. The scene will show early Britons with some of their ancient Druid worship, and also introduce early pottery and lead-miners from Wetton, in a pastoral setting. A Roman legion will pass through on the way to Chester.

(2) An ecclesiastical episode, bringing in the history of the Seventh and Eighth centuries, centered in the legend of Wulfhere and St. Chad at Sonte.

(3) An episode in connection with the Manorial Court of John of Gaunt.

(4) An episode in connection with the dissolution of Hulton Abbey.

(5) An episode illustrating the life of the early potters at the beginning of coal mining, pre-Wedgwood period (Astbury, Toft, Twyford, etc.).

(6) Part 1: A Wedgwood episode introducing Bentley, Whieldon, Wesley, Darwin, Boulton, and Watt. Part 2: The potteries transport and the part Wedgwood played in it; depicting early transport pack horses leading up to the turnpike road agitation, and later the Grand Trunk Canal, introducing Brindley, etc.

* *Evening Sentinel*, Stoke-on-Trent, England, November 25, 1929.

(7) The post-Wedgwood political and industrial unrest, introducing a Chartist scene on the Crown Bank, Hanley, with Thomas Cooper, and the dispersing of the crowds by the Militia.

(8) An episode showing the modern development of the industries of the district.

(9) Grand Finale.

Tattoo Program

The following outline of the Tattoo has been prepared:

The Tattoo will open with the two smallest buglers in the battalions advancing from either side to the center of the stage, and blowing the Advance. From one side, as the last note of the buglers dies away, the roll of the drums will be heard.

(1) The massed bands will march on. These bands will conclude their program of marching and counter-marching by playing a selection of well-known airs ("Tipperary," "Pack Up Your Troubles," etc.).

(2) To the music of the orchestra the recruits from Lichfield will enter in singlets at a jog-trot. They will give their display of physical training without music, and double off to music.

(3) Battalions advance from either side in slow march to leave a space in the center; then from the back the colors advance, pass between the battalions to the front, and troops present arms.

(4) The background will be a representation of the pursuits of the Army in peace time. It is hoped to stage a hunting scene. War will be represented by a mimic battle, followed by the buglers playing the Last Post in front of a projected picture, from a lantern slide, of the Cenotaph with troops massed in front. The Tattoo will close with the National Anthem.

CALENDAR OF CONVENTIONS

Organization	Date	Place
AMERICAN CERAMIC SOCIETY	February 16–22, 1930	Toronto, Canada
American Chemical Society	Week of April 7, 1930	Atlanta, Ga.
American Electrochemical Society	May 29–31, 1930	St. Louis, Mo.
American Foundrymen's Assn.	May 12–17, 1930	Cleveland, Ohio
American Institute of Mining and Metallurgical Engineers	February 17–20, 1930	New York, N. Y.
American Society of Mechanical Engineers		
Fiftieth Anniversary Meeting	April 5–9, 1930	New York, N. Y. and Washington, D. C.
Semi-Annual Meeting	June 9–12, 1930	Detroit, Mich.
American Society for Testing Materials	June 24–28, 1930	Atlantic City, N. J.
Assn. of Scientific Apparatus Makers of U. S.	May, 1930	Atlantic City, N. J.
Common Brick Manufacturers' Assn. of America	February 3–8, 1930	Memphis, Tenn.
International Heating and Ventilating Exposition	January 27–31, 1930	Philadelphia, Pa.
Manufacturing Chemists' Assn. of the U. S.	May, 1930	New York, N. Y.
National Academy of Sciences	April 28–30, 1930	Washington, D. C.
National Assn. of Manufacturers of Heating and Cooking Appliances	May, 1930	New York, N. Y.
Sand-Lime Brick Assn.	February 4–6, 1930	New York, N. Y.
Structural Clay Tile Assn.	February 12–14, 1930	Columbus, Ohio
Tile and Mantel Contractors' Assn.	April 8–12, 1930	New Orleans, La.

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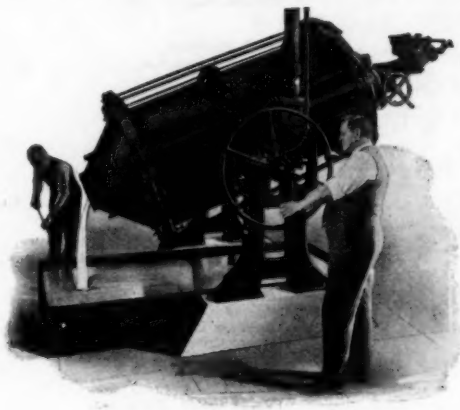

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Lake County Clay Company

turn back to the spirit of friendliness and good fellowship they enjoyed all through the year 1929 with so many business acquaintances. May the present year bring you health, happiness and prosperity.

President

Metuchen, N. J.

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F

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G

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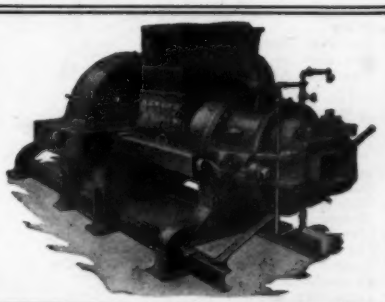

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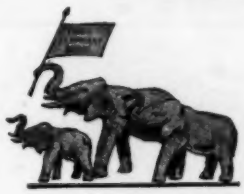

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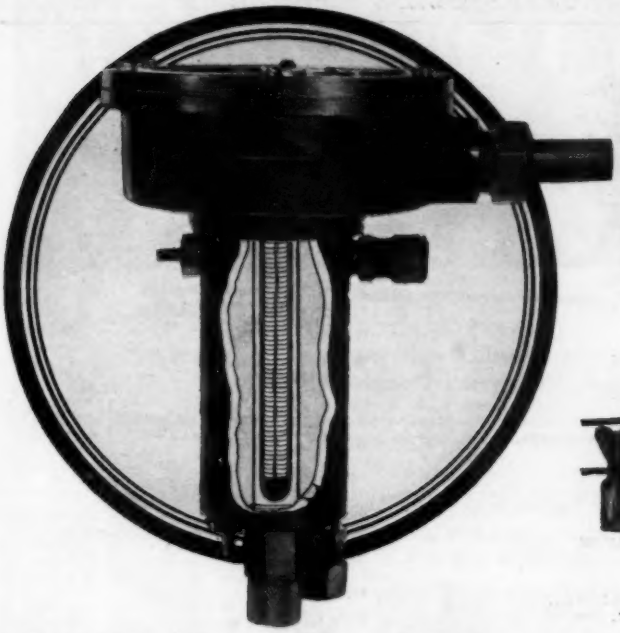

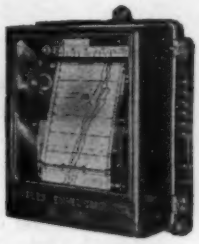

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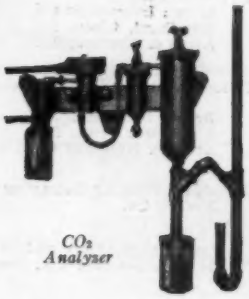

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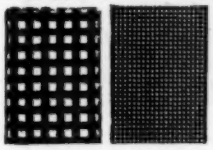
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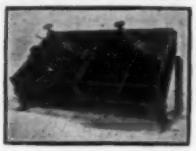

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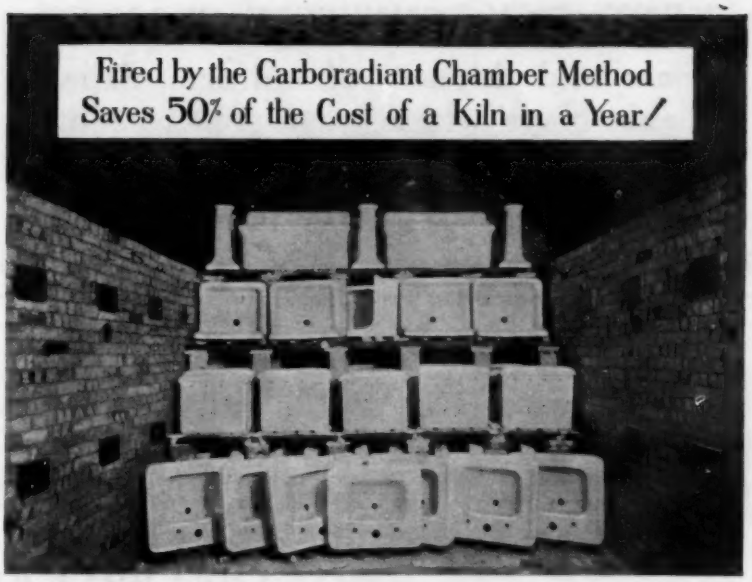

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